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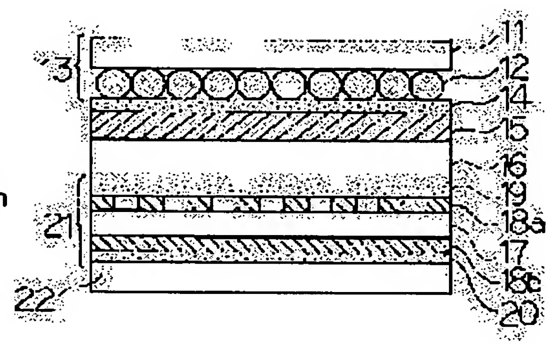
(54) MAGNETIC PARTICLE ROTATION TYPE DISPLAY ELEMENT

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a lightweight thin display element which displays a sharp image with low power consumption.
SOLUTION: Magnetic particles 12 having 5 to 30 μm particle size and colored into two colors, for example, white and black are arranged as rotatable, for example, by encapsulating in microcapsules on a transparent supporting body 11. A memory layer 15 having perpendicular magnetic anisotropy on which a protective film 14 is formed and a supporting body 16 are applied on the rotating particle layer 13. An electric wiring layer 21 prepared by patterning electric wirings 18a, 18b in a matrix state, for example, in X-Y directions on both faces of a supporting body 17 as an insulating layer and further forming protective films 19, 20, and a supporting body 22 are successively applied on the supporting body 16. If necessary, an antireflection film is applied on the supporting body 11 of the rotating particle layer 13.



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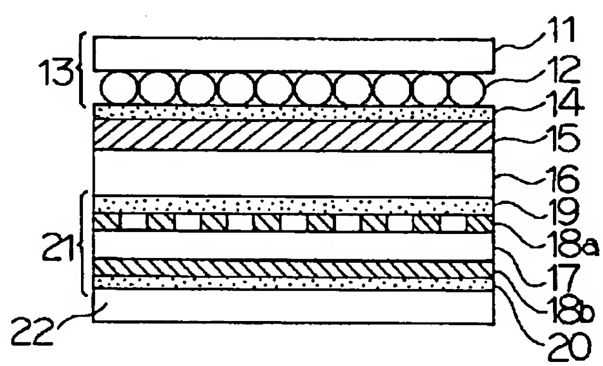
(54)【発明の名称】　磁気粒子回転型表示素子

(57)【要約】
【課題】　低消費電力で鮮明な画像表示が可能な軽量薄型の表示素子を得る。
【解決手段】　透明の支持体１１に２色例えば白黒に色分けされた５～３０μm粒径の磁気粒子１２が回転可能に、例えばマイクロカプセルに内包されて配列されている。この回転粒子層１３に、保護膜１４が形成された垂直磁気異方性を有するメモリー層１５および支持体１６が配設され、さらに絶縁層となる支持体１７の両面に電気配線１８ａ、１８ｂが例えばＸ－Ｙ方向にマトリクス状にパターン形成され保護膜１９、２０が形成された電気配線層２１と、支持体２２が順次配設されている。また、回転粒子層１３の支持体１１には、必要に応じて反射防止膜が設けられる。



【特許請求の範囲】

【請求項１】　回転により色替え可能に色分けされ着磁された磁気粒子が透明支持体上に回転可能に配列される画像表示層と、
前記画像表示層の画素単位に前記磁気粒子を回転させる磁界を発生する電気配線層と、
前記画像表示層と電気配線層の間に介挿され、前記電気配線層によって磁化され前記画像表示層の磁気粒子に磁界を付与する垂直磁気異方性を有するメモリー層とを具備することを特徴とする磁気粒子回転型表示素子。

【請求項２】　請求項１記載の磁気粒子回転型表示素子において、前記磁気粒子の平均粒子径が５μm～３０μmの範囲にあることを特徴とする磁気粒子回転型表示素子。

【請求項３】　請求項１記載の磁気粒子回転型表示素子において、前記磁気粒子が透明なマイクロカプセル内に回転可能に潤滑性液体とともに封入されていることを特徴とする磁気粒子回転型表示素子。

【請求項４】　請求項１記載の磁気粒子回転型表示素子において、前記磁気粒子が透明の板に規則的に設けた孔の中に封入されていることを特徴とする磁気粒子回転型表示素子。

【請求項５】　請求項１記載の磁気粒子回転型表示素子において、前記磁気粒子が半球ずつ２色に色分けされ、一方の色が白色であることを特徴とする磁気粒子回転型表示素子。

【請求項６】　請求項１記載の磁気粒子回転型表示素子において、前記磁気粒子が窒化鉄を含有することを特徴とする磁気粒子回転型表示素子。

【請求項７】　請求項１記載の磁気粒子回転型表示素子において、前記電気配線層が、絶縁層を介して互いに直交する方向にそれぞれ導電性配線が平行に画素ピッチで設けられた一対の配線パターン層を有することを特徴とする磁気粒子回転型表示素子。

【請求項８】　請求項７記載の磁気粒子回転型表示素子において、前記電気配線層が、隣り合う平行な導電性配線の電流が互いに逆方向に流れるよう制御されることを特徴とする磁気粒子回転型表示素子。

【請求項９】　請求項１記載の磁気粒子回転型表示素子において、前記電気配線層が、絶縁層を介して互いに直交する方向にそれぞれ導電性配線が画素ピッチで設けられてなるとともに、各導電性配線が、前記絶縁層を介して交差する部位にコの字が重なるようなコイル形状を有することを特徴とする磁気粒子回転型表示素子。

【請求項１０】　請求項１記載の磁気粒子回転型表示素子において、前記画像表示層の透明支持体に反射防止膜が形成されていることを特徴とする磁気粒子回転型表示素子。

【請求項１１】　請求項１記載の磁気粒子回転型表示素子において、前記画像表示層の透明支持体と前記電気配線層の支持体が同一材料で構成されていることを特徴とする磁気粒子回転型表示素子。

【請求項１２】　請求項１記載の磁気粒子回転型表示素子において、前記画像表示層の透明支持体の上から前記磁気粒子を回転させる磁界を発生する磁気ペンを具備することを特徴とする磁気粒子回転型表示素子。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、磁性体からなる粒子の回転により粒子表面の光学的状態が変化して図形や文字等の画像を表示する磁気粒子回転型表示素子に関する。

【０００２】

【従来の技術】１９７５年にＭａｇｎａｖｏｘ社より、粒子を磁界によって回転させるＭＰＤ（ｍａｇｎｅｔｉｃ　ｐａｒｔｉｃｌｅ　ｄｉｓｐｌａｙ）が提案された（Ｌ．Ｌ．Ｌｅｅ：ＩＥＥＥ　Ｔｒａｎｓａｃｔｉｏｎ　ｏｎ　Ｅｌｅｃｔｒｏｎ　Ｄｅｖｉｃｅｓ，ＥＤ－２２，Ｐ７５８）。このＭＰＤには、半球面が白色、残り半球面が黒色に着色された磁性体球状粒子が用いられた。その後、個々の粒子をマイクロカプセル化し、これを透明シートに敷き詰める方法に改良されている。

【０００３】図４は、上記ＭＰＤの構成例を示すもので、（ａ）に示すように、上から順に回転粒子１の表面色により画像を表示する回転粒子層２と、磁界発生機能を有する電気配線層３と、電気配線層３によって磁化され回転粒子層２に回転磁界を与えるメモリー層４と、基板５が積層されている。回転粒子層２には、白黒に色分けされた酸化鉄の磁性体からなる回転粒子１が、図４（ｂ）に示すように、マイクロカプセル６に内包されて配列されている。電気配線層３は、ポリイミドからなる支持体３ａの両面に、図４（ｃ）に示すように、銅配線３ｂ、３ｃがＸ－Ｙマトリックス状に張り巡らされて構成され、各２本のＸラインとＹラインで囲まれた面の磁場によって、画素部に相当する部位の磁性体層の磁化方向を反転させる。メモリー層４は数ミリの厚さの磁性体層からなり、図４（ｄ）に拡大して示すように、回転粒子層２に対して垂直方向に磁界を印加できるように、形状磁気異方性を利用すべく格子状に画素単位の角柱に分割されている。このＭＰＤの画素サイズは０．５～１．７ｍｍであり、粒子径３０～４００μｍの回転粒子が用いられた。

【０００４】

【発明が解決しようとする課題】ところで、上記ＭＰＤでは次のような問題点があった。

①電気配線層の発生磁界で高速度にまずメモリー層を磁化した後、メモリー層の磁界でゆっくりと回転粒子層の粒子を回転させるが、回転粒子層／電気配線層／メモリー層の構成では、回転磁界を与えるメモリー層が回転粒子層と離れているためメモリー層の磁界を伝えにくく、

粒子回転にばらつきが生じて、鮮明な画像が得にくかった。

【０００５】②メモリー層は回転粒子層と離れているため大きな記録磁界強度が必要で、厚膜のメモリー層が大きな記録磁界強度を得るために、電気配線層の発生磁界を大きくする必要があった。
③回転粒子の粒子径が３０μm以上と大きいため、画像分解能は低かった。
④メモリー層は格子状に形成されるが、このような複雑形状の作製は困難なため、作製コストが高かった。

【０００６】本発明は、上記従来技術の問題点に対処してなされたもので、メモリー層を薄くかつ簡単形状にして、回転粒子層に近接して設けることにより、製造が容易で、低消費電力かつ高分解能の磁気粒子回転型表示素子を提供することを目的とする。

【０００７】

【課題を解決するための手段】すなわち、請求項１の発明は、回転により色替え可能に色分けされ着磁された磁気粒子が透明支持体上に回転可能に配列される画像表示層と、前記画像表示層の画素単位に前記磁気粒子を回転させる磁界を発生する電気配線層と、前記画像表示層と電気配線層の間に介挿され、前記電気配線層によって磁化され前記画像表示層の磁気粒子に磁界を付与する垂直磁気異方性を有するメモリー層とを具備することを特徴とする磁気粒子回転型表示素子である。

【０００８】請求項１の発明においては、電気配線層に例えば画像信号に基づいて制御された電流が流れ、画像信号に対応した画素単位の磁界が発生すると、メモリー層が画素単位に磁化され、画像表示層の磁気粒子に画像信号に対応した画素単位の磁界を付与する。これにより、画像表示層の各磁気粒子は画像信号に対応した回転状態に制御され、各磁気粒子が透明支持体側に向けた色によって画像が形成される。この各磁気粒子の回転による画像は、電気配線層によって次の磁界が発生するまでメモリー層によって保持される。ここで、メモリー層が画像表示層に近接して設けられ、かつ垂直磁気異方性を有することで、メモリー層を画素単位の角柱に形成することなく、薄膜で形成することが可能となるとともに、記録磁界強度が小さくてすみ、電気配線層に流れる電流の低減化すなわち省電力化が可能となる。

【０００９】請求項２の発明は、請求項１の磁気粒子回転型磁気表示素子において、磁気粒子の平均粒子径が５μm～３０μmの範囲にあることを特徴とする。磁気粒子の平均粒子径を３０μm以下とすることにより、画素サイズを１２６μm以下とすることができ、２００ｄｐｉ以上と高分解能画像を得ることが可能となる。また、粒子径を５μm以下とすると、１個当たりの磁化が小さくなり、磁界による回転が困難となる。

【００１０】請求項３の発明は、請求項１の磁気粒子回転型磁気表示素子において、磁気粒子が透明なマイクロカプセル内に回転可能に潤滑性液体とともに封入されていることを特徴とする。この発明においては、磁気粒子がマイクロカプセルに内包されて透明支持体上に配列されることで、磁界によって回転自在となり、鮮明な画像形成が可能となる。

【００１１】請求項４の発明は、請求項１の磁気粒子回転型磁気表示素子において、磁気粒子が透明の板に規則的に設けた孔の中に封入されていることを特徴とする。この発明においては、磁気粒子が規則的に設けた孔の中に封入されることで、マイクロカプセルに内包された状態と同様に磁界によって回転自在となるとともに、磁気粒子をより規則的に配列することが容易となり、解像度の高い画像が得られる。

【００１２】請求項５の発明は、請求項１の磁気粒子回転型磁気表示素子において、磁気粒子が半球ずつ２色に色分けされ、一方の色が白色であることを特徴とする。画像表示層に配列される磁気粒子がすべて白黒に色分けされた場合にはモノクロ画像が表示される。白と組み合わせて複数色が用いられて画像表示層に配列された場合にはカラー画像が表示される。

【００１３】請求項６の発明は、請求項１の磁気粒子回転型磁気表示素子において、磁気粒子が窒化鉄を含有することを特徴とする。この発明においては、飽和磁化の大きな窒化鉄を磁気粒子の磁性体に用いることで、大きな回転トルクが得られ、少ない電流値で磁気粒子の回転制御すなわち画像形成が可能となる。

【００１４】請求項７の発明は、請求項１の磁気粒子回転型磁気表示素子において、電気配線層が、絶縁層を介して互いに直交する方向にそれぞれ導電性配線が平行に画素ピッチで設けられた一対の配線パターン層を有することを特徴とする。この発明においては、配線パターンをＸ方向とＹ方向に互いに接することがないように高格子状に設けることで、画素単位に磁界を発生することが可能となるとともに、電気配線層の作製が容易で、安価な表示素子が得られる。

【００１５】請求項８の発明は、請求項７の磁気粒子回転型磁気表示素子において、電気配線層が、隣り合う平行な導電性配線の電流が互いに逆方向に流れるよう制御されることを特徴とする。この発明においては、Ｘ方向とＹ方向の配線パターンによって形成される格子の中心に大きな回転磁界が得られるので、少ない電流値で磁気粒子の回転制御すなわち画像形成が可能となる。

【００１６】請求項９の発明は、請求項１の磁気粒子回転型表示素子において、電気配線層が、絶縁層を介して互いに直交する方向にそれぞれ導電性配線が画素ピッチで設けられてなるとともに、各導電性配線が、絶縁層を介して交差する部位にコの字が重なるようなコイル形状を有することを特徴とする。この発明においては、導電性配線が絶縁層を介して交差する部位のコの字の中心に大きな回転磁界が得られるので、少ない電流値で磁気粒

子の回転制御すなわち画像形成が可能となる。

【００１７】請求項１０の発明は、請求項１の磁気粒子回転型表示素子において、画像表示層の透明支持体に反射防止膜が形成されていることを特徴とする。この発明においては、磁気粒子の色調がより明瞭となり、画像のちらつきが抑制され、より鮮明な画像が得られる。

【００１８】請求項１１の発明は、請求項１の磁気粒子回転型表示素子において、画像表示層の透明支持体と電気配線層の支持体が同一材料で構成されていることを特徴とする。この発明においては、画像表示層と電気配線層との間で温度変化や湿度変化に伴う支持体の伸縮によるずれが抑制され、書き換え時の画像ずれを防いで鮮明な画像形成が可能となる。

【００１９】請求項１２の発明は、請求項１の磁気粒子回転型表示素子において、画像表示層の透明支持体の上から磁気粒子を回転させる磁界を発生する磁気ペンを具備することを特徴とする。この発明においては、透明支持体の上から磁気ペンにより任意に画像を追加したり、消去したりすることが可能となる。

【００２０】

【発明の実施の形態】以下、図面に基づいて本発明の実施の形態を説明する。図１は、本発明の磁気粒子回転型表示素子の一実施の形態を示す断面図である。この図において、表面観測側から、透明の支持体１１に複数色通常は２色に色分けされた磁気粒子１２が回転可能に配列されている。この回転粒子層１３に、保護膜１４が形成されたメモリー層１５および支持体１６が配設され、さらに絶縁層となる支持体１７の両面に電気配線１８ａ、１８ｂがパターン形成され保護膜１９、２０が形成された電気配線層２１と、支持体２２が順次配設されている。また、回転粒子層１３の支持体１１には、必要に応じて反射防止膜（図示せず）が設けられる。

【００２１】磁気粒子１２は磁性体を含んでおり、２色に色分けされた一方がＮ極、他方がＳ極になるように着磁されて永久磁石となっている。磁気粒子１２としては、磁性体の超微粒子とポリエチレンやフェノール樹脂などのポリマーとの混合物が用いられる。また、磁性体単独の微粒子を用いてもよい。この場合は、ポリマーとの混合物よりも磁化が強くなり、従って回転のためのトルクが強くなる。このため、回転に要する磁界強度は小さくて済み、電気配線層２１の電流値を低減することができるので、省電力化を図ることができる。磁気粒子１２の形状は、楕円や多角形でもかまわないが、回転を滑らかに行うためには球形が好ましい。

【００２２】磁気粒子１２の粒子径は、３０μｍ以下が好ましい。従来技術のＭＰＤでは３０μｍ以上の粒径の回転粒子が用いられたが、これは画素サイズが０．５～１．７mmの大きさであったためであり、２００ｄｐｉ以上と高分解能画像を得ようとする場合には、画素サイズが１２６μｍ以下となり、磁気粒子の粒径が３０μｍ以上では大きすぎて十分な分解能が得られない。一方、粒子径はあまり小さいと１個当たりの磁化が小さくなり、磁界による回転が不可能となる。また回転機能付与処理、たとえばマイクロカプセル化なども困難になる。磁気粒子１２に用いる磁性体の飽和磁化にもよるが、５μｍ以上が好ましい。

【００２３】また、磁性体の粒径が小さくなると磁化が小さくなるので、磁性体としては飽和磁化の大きい方が回転トルクが大きくなって好ましい。一般に用いられる酸化鉄（γ－Fe_2O_3、Fe_3O_4）は飽和磁化が７０～８０ｅｍｕ／ｇであるが、窒化鉄（Fe_4N）は飽和磁化が１２０～１４０ｅｍｕ／ｇと約２倍大きく好ましい。

【００２４】磁性体は保磁力が５００Ｏｅ以上の半硬磁性体または硬磁性体で、色は一般的に黒色であるが、黄色や茶色または緑色など他の色でもかまわない。黒色磁性体としては、Ｆｅ、Ｃｏ、Ｎｉ、Fe_2O_3、Fe_3O_4、Ｃｏフェライト、ＭｎＺｎフェライトなどの各種フェライトがある。磁気粒子１２の色は通常白と黒の２色に半球ずつ色分けされるが、磁性体が黒であれば半球だけ白に着色すればよい。背景の色を白以外にしたい場合には、白色の代わりにその背景色が選択される。カラー画像を得たい場合には、白と、たとえば赤（Ｒ）、緑（Ｇ）、青（Ｂ）などのいわゆる３原色の着色が施される。場合によっては３色以上を着色してもかまわない。たとえば、上記白と黒の５色に色分けしてあれば、フルカラーを表示することができる。３原色の粒子着色材としては、メチレンブルー、コンゴーレッド、ベンゾイエローＴＺ等の染料や、オイルブルー、オイルクリーン、オイルイエロー、ベンジジンイエローなどが用いられる。また、磁気粒子１２が配列された回転粒子層１３上に反射防止膜を設けることで、磁気粒子１２の色調がより明瞭に確認することができるようになる。

【００２５】黒およびＲ、Ｇ、Ｂの各色微粒子の片面を白色に着色するには、コーティング法やスプレー法などいろいろ考えられるが、最も容易な方法としては、微粒子を一層形成し固定した後、真空蒸着法を用いてアルミニウム膜を被着する方法がある。アルミニウム膜は金属光沢を有するが、５～３０μｍ径の微粒子になると、この金属光沢は感じられなくなり、いわゆる白色として観察される。色分けされた磁気粒子１２の表面には、表面凹凸を減少させるため、あるいは表面潤滑性を向上させるため、有機物や無機物を薄くコーティングしてもよい。

【００２６】上記のように着色され着磁された磁気粒子１２は回転機能を付与され、支持体１１上に配置される。回転機能を付与する方法はいくつかあるが、その１つとして磁気粒子１２を透明なマイクロカプセルで封入する方法が挙げられる。マイクロカプセルの外殻を構成する材料としては、アクリル系、メタクリル系、ポリエ

ステル、ポリスチレン、ポリウレア、ポリアミド、エポキシなど一般的な樹脂を単独または混合して使用することができる。マイクロカプセルの製造方法としては、磁気粒子を分散させたエマルジョンの内側と外側の両方からモノマーを供給する界面重合法、磁気粒子を分散させたエマルジョンの内相あるいは外相の一方からモノマーを供給するｉｎ－ｓｉｔｕ法、その他公知のマイクロカプセル化技術が用いられる。マイクロカプセルの外殻は、ある程度の押し圧に耐える機械的強度、透明性、化学的安定性などの特性が求められる。また、マイクロカプセル内に含有させる流動体は、磁気粒子１２の回転をスムーズにするための潤滑作用が最も求められ、水、油、アルコール等の液体が用いられる。

【００２７】回転機能を付与された磁気粒子１２は、透明な支持体１１上に配列される。この配列方法にも各種あり、同一サイズ粒子を規則正しく１層だけ配列することが好ましいが、１．５層程度または、２種の大小粒子を多層に配列してもよい。透明支持体としては、ＭＭＡ（メチルメタクリレート）、ＰＭＭＡ（ポリメチルメタクリレート）、ポリカーボネート、ポリプロピレン、アクリル系樹脂、スチレン系樹脂、ＡＢＳ樹脂、ポリアリレート、ポリサルフォン、ポリエーテルサルフォン、エポキシ樹脂、ポリー４－メチルペンテンー１、フッ素化ポリイミド、フッ素樹脂、フェノキシ樹脂、ポリオレフィン系樹脂、ナイロン樹脂などの透明樹脂が用いられる。

【００２８】同一サイズ粒子を規則正しく１層だけ配列する場合の方法として、透明プラスチック製の板に規則的に設けた孔の中に微粒子を封入させる方法がある。孔の高さは１個の粒子が回転できるくらいであり、縦と横は複数個が入るサイズである。この場合、磁気粒子１２に回転機能を付与するマイクロカプセルは必要がない。透明プラスチック板の孔がマイクロカプセルの代わりとなる。この孔の中に摩擦抵抗低減用液体（たとえばオイル）を封入すればさらによい。この方法の利点は微粒子を規則正しく配列することができるために、高品質画像が得られることである。なお、この方法はランダムにも配列できることはもちろんである。

【００２９】この透明プラスチック板に孔を形成する方法としては、次のような方法がある（Ｊ　Ｖａｃ　Ｓｃｉ　Ｔｅｃｈｎｏｌ　Ｂ　Ｖｏｌ．１６，　Ｎｏ．６　ｐ．３８２５－３８２９，１９９８参照）。

１．例えばシリコンウェハの上に、電気メッキのための金属たとえばＰｔ層を設ける。

２．この上にＣＶＤ法などでSiO_2 の膜を作る。この膜厚が微粒子を入れる孔の深さをきめる。

３．この上に透明プラスチックとして例えばＰＭＭＡをスピンコート法などで設ける。

４．リソグラフィーで孔パターンをＰＭＭＡ上に露光する。

５．ＰＭＭＡ上にＣｒを蒸着法などで設ける。

６．反応性イオンエッチングでＰＭＭＡとＣｒ層に孔を形成する。

【００３０】メモリー層１５は、従来のＭＰＤと違い、回転粒子層１３に接して設けられる。また、メモリー層１５は垂直磁気異方性を有する磁性体層からなり、一様な膜厚にて形成される。すなわち、メモリー層１５として、垂直磁気異方性定数Ｈｋが２ＫＯｅ以上、好ましくは４ＫＯｅ以上である垂直磁化膜が用いられる。この垂直磁化膜を用いることによって、同一膜厚の面内磁化膜の場合よりも、メモリー層面の垂直方向により大きな発生磁界が得られるので、よりメモリー層を薄くすることができる。

【００３１】メモリー層１５は電気配線層２１によって発生した磁界によって磁化され、さらに磁化されたメモリー層１５の磁界によって回転粒子層１３の磁気粒子１２の回転を支援するとともに、その回転状態を保持して画像の乱れを防止する機能を有する。すなわち、電気配線層２１の発生磁界方向は、電流方向を逆にすることで変えられるが、この発生した磁界方向によって、メモリー層１５の画素に対応する指定した場所を＋またはーに磁化する。この磁化は１画素ごとでもよいし、複数画素ごとでもよい。この１画素の磁化のスピードは、１μｓ以下と高速で行うことが可能であるので、たとえばＡ４サイズのような大画面でも秒のオーダーで可能である。もしこのメモリー層１５がない場合には、磁気粒子１２の回転を各粒子ごとに電気配線層２１の磁界で行うことが必要となる。磁気粒子回転は速くても２０ｍ秒程度かかるので、Ａ４サイズでは長時間かかってしまう。電気配線層２１による磁界印加方法は色々あり、同時に複数個ずつ印加していく方法を用いれば速く画像が得られるが、しかし同時に印加する画素数が多くなればなるほど、同時に流れる電流値も多くなる。１Ａ以上の電流を流すことは装置サイズなどの点で実用上困難であるため、メモリー層１５は画像を高速度で得るために必須である。

【００３２】また、回転した磁気粒子１２は、画像が変化しないように、次の回転制御時の再書き換えまで固定しておく必要がある。この場合にも、メモリー層１５を設けることで、メモリー層１５の磁化は時間によって変化しないので、永久磁石である磁気粒子１２は同一方向を向いたまま固定される。なお、回転後の磁気粒子１２を固定する方法としては、メモリー層１５の設置以外にも、磁気粒子１２とマイクロカプセルなどの樹脂層との間に回転後に抵抗が増大するチキソトロピーな液体を用いる方法もある。

【００３３】ところで、磁気粒子１２を回転させるには、この表示素子の面に垂直に磁界を発生させて、永久磁石化された粒子の磁化に引力と斥力を与えることが必要である。従来技術のＭＰＤでは面内異方性を有する磁

性材料を垂直に方向に長い形状として、形状磁気異方性を利用して、垂直方向に磁界が印加できるようにしているが、本実施の形態ではメモリー層１５自体に垂直磁気異方性を与えて、表示素子面に垂直方向に発生する磁界で粒子を回転させる。この垂直磁化膜を用いることにより、画素ごとに磁性体を柱状に加工する必要がなく、一様な層の加工でよいので製造が容易となり、従ってコストを大幅に低下させることができる。

【００３４】垂直磁気異方性を有する垂直磁化膜を作成する方法としては、たとえばバリウムフェライトのような六角板状形状を有する磁性体粉末の塗料を、磁場を印加しながら基板面に平行に六角板を並べて（配向）塗布して、垂直磁化膜を作成する方法がある。同様にバリウムフェライトと樹脂の混合物をロール間を通過させて、各粒子を配向して薄板状に作製する方法もある。また、広く光磁気記録材メディアとして利用されているＴｂＦｅＣｏなどの金属化合物を、スパッタ法などのＰＶＤ法で基板上に作製する方法がある。他にもＰｔＣｏ等の垂直磁気異方性を有する材料をメッキ法で作製する方法やゾル・ゲル法で作製する方法もある。本発明では材料や作製方法は限定しない。安定性のよい材料で、より薄く、作り易い方法が選定される。

【００３５】次に、メモリー層１５の磁化に用いる電気配線層２１について説明する。電気配線１８ａ、１８ｂに電流が流れることよって発生する磁場と各磁気粒子１２の残留磁化の相互作用（引力または斥力）によって、磁気粒子１２をマイクロカプセル内で回転させることができる。回転に必要な磁場強度は小さく１０ガウス程度でよいので、電気配線１８ａ、１８ｂは、それぞれＸ、Ｙ方向に直線状に設けて、互いに格子を形成するように配線する方法で可能である。この場合は配線形状が単純で作製が容易であるという利点がある。その際、図２に示すように、Ｘ方向およびＹ方向において、それぞれ２本線を１ペアーとし、２本線には逆方向に電流を流して目的の画素に磁界を発生させるようにしてもよい。

【００３６】この外に、電気配線１８ａ、１８ｂを、Ｘ、Ｙ方向の各単線に、図３に示すように、各画素に対応させてコの字状のコイルを設け、その１ターンのコイルがＸ、Ｙ方向で絶縁層を介して重なるように形成してもよい。もちろん２ターン以上のコイルを各画素位置に対応して設ければ、励磁に必要な電流値が小さくて済み好ましいが、単層での作製が不可能となり、中間に絶縁層を含めた多層で配線を構成する必要が生じる。また上下の配線位置を合わせることが困難となる。なお電気配線による発生強磁場と画素の位置は一致するように作製される。

【００３７】電気配線１８ａ、１８ｂは、上記いずれの配線方法においても、目的の画素部以外にも磁界が発生しており、目的の画素部でのみ磁気粒子１２を回転可能なように、磁気粒子１２の回転に必要な力にはしきい値が必要である。このようなしきい値は、たとえばマイクロカプセルと磁気粒子間の液体の粘度などで制御される。このような液体の粘度調整には、アルギン酸ナトリウム、ポリビニルアルコール、変性ポリアクリル酸ナトリウム、変性ポリアクリル酸エマルジョン、変性ポリアクリル酸スルホン酸塩などの粘度調整材が用いられる。特に、アルギン酸ナトリウム、ポリビニルアルコールが好ましい。

【００３８】また、電気配線１８ａ、１８ｂは、いずれの配線方法においても、ポリイミドフィルムなどの絶縁層の裏と表の両面に銅層を蒸着法、スパッタ法、メッキ法などにより形成し、この銅層を配線パターンを除いてエッチングすることによって形成することができる。このフォトリソグラフィー法以外にも、転写法を用いて配線パターンを形成することもできる。たとえば、１．導電性基板上にレジストを形成後、パターン化する。２．この上に電気メッキ法で、金属たとえば銅を設ける。
３．この上にたとえばメッキ法で接着剤を付着させる。
４．この接着剤面を下にして、たとえばプラスチック基板上に転写して、電気配線を形成する。この転写法は、低コストで大面積に容易に対応することができ、また極細配線や立体配線の作成が容易であるという利点を有する。なお、電気配線に用いられる材料は一般的な銅が電気抵抗値の点から好ましいが、Ａｕ、Ａｇ、Ａｌ、Ｐｔなどその他の導電性材料も用いられる。また透明導電膜として一般的なＩＴＯ膜を用いてもよい。

【００３９】また、傷や剥離などの損傷を防止するために、図１に符号１４、１９、２０で示すように、保護膜を設けることが、デバイスの耐久性の点から好ましく、ＳｎＳ、ＳｉＯ、SiO_2、ＩＴＯ、ＺｒＣ、ＴｉＣ、MgF_2、ＭｇＯ、ＢｅＯ、ZrO_2、Y_2O_3、Al_2O_3、Al_2O_3/Ta_2O_5、ＳｉＡｌＯＮ、ＡｌＮ、Si_3N_4、ＳｉＣＮ：Ｈなどが用いられる。有機樹脂保護膜としては、重合性モノマーおよびオリゴマーを主成分とする光硬化性樹脂組成物や熱光硬化性樹脂組成物を用いることができる。膜厚は５０～１０００ｎｍが望ましい。

【００４０】回転粒子層１３の画像はまた、上記の電気配線層２１によって形成するだけでなく、支持体１１の反対側すなわち画像を見る側から形成することも可能である。たとえばコイル中に鉄心を設けてペン先とした磁気ペンにより、画像形成することも可能である。ペン先はある方向の通電時のみ書き込みが可能で、これとは逆の方向に通電した場合は、画像を消すことができるように、磁気粒子１２の着磁設定との組み合わせで可能である。円筒状の細い永久磁石をペン先とした場合は、先端を機械的に反転する必要があり不便であるが、電磁石を用いた場合は、ボタン操作により容易に磁界方向を逆転させることができる。

【００４１】なお、磁気ペンの移動すなわち追記動作に

よって画素部に磁界が発生した場合、電気配線層２１に電流が流れる。この電流を検知する電流検知器を各配線端に配置すれば、タッチパネルなどの画像検出素子を特別に配置しなくても、低コストで容易に追記画像を表示と同時に記録することができる。

【００４２】磁気粒子１２は前にも述べたように、白黒だけでなく、さらにＲ、Ｇ、Ｂの格色に着色することができるので、電気配線層２１によって発生する磁場によって粒子回転を制御することによって、カラー画像も可能となる。この場合白黒とＲＧＢの各色に配色された磁気粒子１２は、保磁力や磁性の種類（反強磁性など）を変えて配置することも可能である。

【００４３】また、表示素子最表面には、素子表面の保護と支持体の機能を併せ持つ透明層である支持体１１が設けられる。この支持体１１を通して、磁気粒子１２によって作られた画像コントラストを観察することになる。この場合、支持体１１の表面側で反射した光は、画像を乱す要因となる。したがって、この反射光発生を防止するための反射防止膜を設けることにより、より鮮明な画像を得ることができる。反射防止膜に用いられる材料は、透明でかつ熱的に安定な物質が適し、例えば金属や半金属の酸化物、窒化物、カルコゲン化物、フッカ物、炭化物、およびこれらの混合物であり、具体的には SiO_2、ＳｉＯ、Al_2O_3、GeO_2、In_2O_3、Ta_2O_5、TeO_2、TiO_2、MoO_3、WO_3、ZrO_2、Si_3N_4、ＡｌＮ、ＢＮ、ＴｉＮ、ＺｎＳ、ＣｄＳ、ＣｄＳｅ、ＺｎＳｅ、ＺｎＴｅ、ＡｇＦ、PbF_2、MnF_2、NiF_2、ＳｉＣなどの単体あるいはこれらの多層膜である。各膜厚は５～２００ｎｍ、好ましくは５～３０ｎｍの範囲にするのがよい。膜は各種のＰＶＤ、ＣＶＤ法を用いて形成される。

【００４４】また、回転粒子層１３が形成される透明な支持体１１と、電気配線層２１が形成される支持体１７には、プラスチック材料を用いる。これは表示素子全体を軽く、薄くするためであるが、プラスチック材料は熱や湿度による伸縮が大きい。一度表示した画像は、温度や湿度の影響を受けて画素位置がずれる。このずれは大きな画面になる程大きくなる。新たな画像を同一表示素子に表示する場合、もとの電気配線層２１の画素位置と異なると、上書きできない画像部位が生ずる。したがって、表示層である回転粒子層１３と書き込み層である電気配線層２１の間で温度や湿度によるずれを生じさせないために、回転粒子層１３の支持体１１と、電気配線層２１の支持体１７には、同一プラスチック材料を用いることが好ましい。これによって、画像書き換え時に、支持体の伸縮による画像ずれが生じるのを防ぐことがき、電気配線層２１による書き換え不可の画像の発生を極力抑えることができる。

【００４５】上記の説明からも明らかなように、本実施の形態においては、軽量、薄型で、また多少の変形があっても破壊することなく、省電力で高精細な画像形成が可能で、画像上から追記も可能な磁気粒子回転型表示素子を得ることができる。特に、従来メモリー層は柱状で素子厚は厚かったが、垂直磁気異方性を有する薄い膜を用いることにより、装置全体を薄く軽くすることが可能となった。また、磁気粒子回転を支援するメモリー層を回転粒子層に近接して設置することで、磁気粒子回転は数ガウスの磁界強度で可能であるため、メモリー層を磁化する電気配線層の電流値は最大でも１００ｍＡ以下、通常は１０ｍＡ以下で十分となり、より省電力で精度よく画像を表示することが可能となった。

【００４６】

【実施例】以下、本発明の実施例を説明する。

実施例１

平均粒子径が０．２μｍである Fe_3O_4 の超微粒子を、ポリエチレン溶解液に分散した。この分散液を、約１００℃程度に加熱され３００００ＲＰＭで回転中の周辺端部が歯形状の円板に滴下した。この回転円板にぶつかって飛散した粒子は急冷され、表面エネルギーを下げるように真球状に丸くなった。この粒子をドラムに捕集し、平均粒子径が１５μｍ、最大粒子径が３０μｍの Fe_3O_4／ポリエチレン混合（体積比で１／１）黒色微粒子を得た。

【００４７】この真球に近い球形の混合微粒子を、市販の粘着シート上に１層だけとなるように散布した後、空隙をさらに微粒子で充填して固定した。この固定粒子上に真空蒸着法を用いて、アルミニウム薄膜を約１００ｎｍの厚みに形成した。アルミニウム膜は混合微粒子の上半分（白色面積約５０％）に形成され、下半分には被着されていない。シート上の粒子は微粒子のため、メタリックな色でなく、いわゆる白色に観察できた。ＶＳＭ（振動試料型磁力計）で測定した保磁力は１０８Ｏｅ、残留磁化は６７ｅｍｕ／ｇであった。この粒子固定シートをそのまま、電磁石のポールピース間に配置し、１００ガウスの磁界を印加して白色と黒色の中心を結ぶ線と磁化の方向が揃うように磁化した。ついで、各磁気粒子をシートから剥離した。

【００４８】上記磁気粒子を５５℃のゼラチン水溶液に入れ攪拌した。この溶液にアラビアゴムを加え、ＰＨを下げて酸性にし、さらに液温を２０℃以下に下げて、ゼラチン／アラビアゴムの重合体膜を生成し、硬化してマイクロカプセルを形成した。このマイクロカプセルをシリコンオイル中に浸漬して、マイクロカプセルと磁気粒子の間にシリコンオイルをしみ込ませ、カプセル内で磁気粒子が回転できるようにした。マイクロカプセルを通して白黒の色を確認できた。

【００４９】次に、厚さ１００μｍのポリカーボネート基板の片面に、厚み１００ｎｍのＭｇＯの反射防止膜を真空蒸着法で設け、もう一方の面に紫外線硬化樹脂をコーティングした。上記作製したマイクロカプセルの水溶

液を、ポリカーボネート基板の紫外線硬化樹脂塗布面に垂らして、１層のみの厚みでマイクロカプセルが配列するように振動を加えた。この後、紫外線硬化樹脂にＵＶ光を照射して硬化させ、各マイクロカプセル位置を固定して画像表示部を作製した。

【００５０】次に、厚さ２０μｍのポリカーボネートフィルム上に、ＴｂＦｅＣｏをターゲットとしてスパッタ法を用いて、厚さ０．５μｍの垂直磁化膜を形成した。垂直方向磁界を印加して測定した保磁力は１８００ｅであった。垂直異方性磁界は４．５ＫＯｅであった。この膜上に同様にスパッタ法を用いて、厚さ１００ｎｍのＳｉＮの保護膜を形成した。このようにして作製したメモリー層の保護膜の上に接着剤を用いて前記画像表示部のポリカーボネート基板を外側にして重ねて貼着した。

【００５１】次に、厚さ１００μｍのポリカーボネート基板の片面に１０ｎｍ厚のＮｉ膜をスパッタ法で設けた後、５μｍ厚の銅膜をメッキ法で形成した。この銅膜をフォトリソグラフィー法でパターニングし、エッチング法で銅配線を形成した。配線パターンは３ターンのコイル状とした。またコイル間すなわち画素間のピッチは１２７μｍ（２００ｄｐｉ）とした。この後、さらにスパッタ法で配線パターン上に約１００ｎｍ厚のＳｉＮ膜を保護層として設けた。各配線端には、ＸとＹ方向の配線の交点に順次１つずつコイルによる磁界が発生するような駆動回路を設けた。以上のようにして作製した電気配線層を、マイクロカプセルを配列した画像表示部とメモリー層との張り合わせ品に図１のように重ねて一体化した後、端部を樹脂でシールして表示素子を作製した。

【００５２】ついで、各電気配線に駆動回路を用いて順次電流を流した。電流は各コイル（画素）上の磁気粒子の磁極とは反発するように、方向を制御した。磁気粒子は回転して黒色を示した。同様にして各画素に白黒への移動を生じさせてコントラストを得て白黒画像を得ることができた。画像は透明支持体の表面での反射光によって、ちらついて見えることもなく鮮明で、繰り返し表示させることができた。また、磁気粒子の凹凸は気にならなかった。形成した画像は書き換えるまで半永久的に消えることがなかった。

【００５３】さらに、直径０．８ｍｍ、長さ１５ｍｍの鉄棒に、コイルを形成して電磁石とし、電池とスイッチによって、電流が正負の両方向に流れるようにして、画像表示部の透明支持体の上から像を記入することができる磁界発生用磁気ペンを作製した。上記表示素子の電気配線層に電流を流して画像形成した後、該磁気ペンに正方向に電流を流して、透明支持体上からペンを走らせ画像を消去した。また、負方向に電流を流して、新たに線画像を追加した。画像表示部の透明支持体と電気配線層の支持体には、同一材料のポリカーボネート基板を用いたので、画像書き換えできなかった部位が少なく、画像が鮮明であった。

【００５４】<u>実施例２</u>
実施例１において、磁気粒子として、Fe_3O_4／ポリエチレン混合粒子の代わりに、平均粒子径１５μｍのFe_3O_4の黒色磁性体微粒子を用い、磁気粒子間のくっつきを防止するために、マイクロカプセルの厚みを約２倍になるようにした。他は実施例１と同様にして表示素子を作製した。電気配線に電流を流して得た画像は鮮明であった。また、実施例１の磁気回転粒子より約２倍に飽和磁化が増大した分、粒子重量の増大にもかかわらず、粒子回転トルクが増大してより少ない電流値で回転が可能になり、省電力化を図ることができた。

【００５５】<u>実施例３</u>
実施例１において、平均粒子径０．２μｍのFe_3O_4の超微粒子の代わりに平均粒子径０．２μｍのFe_4Nの黒色磁性体微粒子を用い、Fe_4N／ポリエチレンの混合粒子を磁気粒子として作製した。また、磁気粒子間のくっつきを防止するために、マイクロカプセルの厚みを約２倍になるようにした。他は実施例１と同様にして表示素子を作製し、電気配線に電流を流して得た画像は鮮明であった。また、実施例１の磁気回転粒子より約２倍に飽和磁化が増大した分、粒子回転トルクが増大してより少ない電流値で回転が可能になり、省電力化を図ることができた。

【００５６】<u>実施例４</u>
１００μｍ厚のポリカーボネート基板の両面上に、５μｍ厚の銅膜を真空蒸着法で作製し、この銅膜をフォトリソグラフィー法でパターニングし、エッチング法で銅配線を形成した。配線パターンは図２のように基板の縦と横にほぼ直角に格子状に設けた。上記配線パターンは裏面と表面では９０度回転させて作製し、格子の中心の磁界強度が最大になる分布を示した。これを電気配線層として用い、他は実施例１と同様にして表示素子を作製した。電気配線に電流を流して得た画像は鮮明であった。

【００５７】<u>実施例５</u>
１００μｍ厚のポリカーボネート基板の両面上に、５μｍ厚の銅膜を真空蒸着法で作製し、この銅膜をフォトリソグラフィー法でパターニングし、エッチング法で銅配線を形成した。配線パターンは図３のようにカタカナのコの字の形状とした。上記配線パターンは裏面と表面では９０度回転させて作製し、コの字の中心の磁界強度が最大になるように位置を合わせた。これを電気配線層として用い、他は実施例１と同様にして表示素子を作製した。電気配線に電流を流して得た画像は鮮明であった。

【００５８】<u>実施例６</u>
シリコンウェハの上に、電気メッキのためのＰｔ層を設けた。この上にＣＶＤ法で約２０μｍ厚のSiO_2の膜を作製した。この上にＰＭＭＡ（ポリメチルメタクリレート）をスピンコート法で設けた。ついで格子状の孔パターンをＰＭＭＡ上に露光した後、ＰＭＭＡ上にＣｒ層を蒸着法などで設けた。反応性イオンエッチングを用い

てＰＭＭＡとＣｒ層に孔を作製した。ついで、このようにして規則的に形成された孔中に、実施例１で作製したFe_3O_4／ポリエチレン混合黒色微粒子を入れ、２０μm厚のＰＭＭＡフィルムを張り付けて覆った。２０μm厚のＰＭＭＡフィルム側に、実施例１と同様にしてメモリー層および電気配線層を設けて、表示素子を作製した。電流を流した場合の画像は鮮明であった。

【００５９】比較例１
実施例１の透明支持体／回転粒子層／メモリー層／電気配線層の構成に対して、メモリー層と電気配線層の位置を入れ替えて、透明支持体／回転粒子層／電気配線層／メモリー層の構成にして、あとは実施例１と同様にして表示素子を作製した。実施例１と同様の電流を電気配線層に流したが、回転粒子層とメモリー層の間が大きくなり、回転粒子層の磁気粒子を回転させる磁界の強度が減少して、画像コントラストは実施例１の半分程度であった。

【００６０】比較例２
実施例１のメモリー層をフェライトと樹脂の混合（体積比８／２）塗布層とした。膜厚を厚くして、表面磁束密度を実施例１と同じとした。膜は等方的な磁気特性を示した。その他は実施例１と同様にして表示素子を作製した。電気配線に電流を流したところ、メモリー層の磁界方向が膜面に平行な成分が多いため、磁気粒子の回転角にバラツキが多くなり、画像はボケたものとなった。またメモリー層厚が厚くなったため、電気配線層の発生磁界がメモリー層磁化にとって不足して、従って粒子の回転角が不十分となり表示画像は不鮮明であった。

【００６１】比較例３
実施例１において、磁気粒子の粒径を５μm、３２μm、４６μmとした以外は、まったく同様にして表示素子を作製した。粒子径が大きい磁気粒子を用いたものほど画像の鮮明さがなくなり、３２μm、４６μm径の磁気粒子による画像は、明らかに５μm、１５μm径の磁気粒子による画像よりも見ずらいものであった。

【００６２】比較例４
実施例１において、磁性体超微粒子とポリマーからなる磁気粒子を透明なマイクロカプセル中に封入した後、このマイクロカプセルと微粒子間にシリコンオイルを浸漬しないでポリカーボネート基板に配置した。その他は実施例１と同様にして磁界を加えても、カプセル内で粒子が回転せず、画像は表示されなかった。

【００６３】
【発明の効果】上述したように、請求項１の発明によれば、メモリー層を垂直磁気異方性膜によって形成し、画像表示層に近接して配置することにより、低消費電力で鮮明な画像表示が可能な軽量薄型の表示素子を得ることができる。

【００６４】請求項２の発明によれば、磁気粒子の平均粒子径を５μm～３０μmとすることにより、高分解能の画像を表示することができる。

【００６５】請求項３の発明によれば、画像表示層においてマイクロカプセルに内包した磁気粒子を配列することにより、磁気粒子に回転機能が付与され、磁界によって鮮明な画像を表示することができる。

【００６６】請求項４の発明によれば、画像表示層において透明の板に規則的に設けた孔の中に磁気粒子を封入することにより、磁気粒子に回転機能が付与されるとともに、より規則的に磁気粒子を配列することができ、解像度の高い画像を表示することができる。

【００６７】請求項５の発明によれば、磁気粒子の半球ずつ色分けした一方を白色とすることにより、白黒画像またはカラー画像を容易に表示することができる。

【００６８】請求項６の発明によれば、飽和磁化の大きな窒化鉄を磁気粒子の磁性体に用いることにより、磁気粒子に大きな回転トルクが得られ、少ない電流値で画像を形成することができる。

【００６９】請求項７の発明によれば、電気配線層の配線パターンを絶縁層を挟んで格子状に設けることにより、低コストの製作費で容易に画素単位に磁気粒子の回転を制御することができる電気配線層を得ることができる。

【００７０】請求項８の発明によれば、電気配線層の隣り合う平行な導電性配線の電流が互いに逆方向に流れるよう配線２本１組で電流制御することにより、配線パターンによって絶縁層を挟んで形成される格子の中心に大きな回転磁界を得ることができ、少ない電流値で画像を形成することができる。

【００７１】請求項９の発明によれば、電気配線層の各導電性配線に絶縁層を介して交差する部位にコの字が重なるようなコイル形状を形成することにより、コの字の中心に大きな回転磁界を得ることができ、少ない電流値で画像を形成することができる。

【００７２】請求項１０の発明によれば、画像表示層の透明支持体に反射防止膜を形成することにより、画像のちらつきを抑制して鮮明な画像を観測することができる。

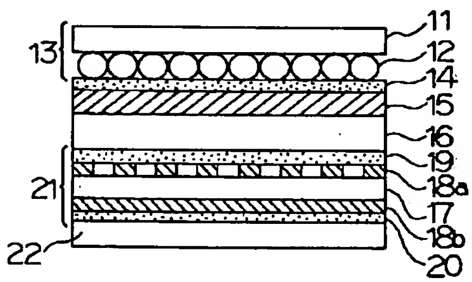
【００７３】請求項１１の発明によれば、画像表示層の透明支持体と電気配線層の支持体を同一材料とすることにより、画像表示層と電気配線層との間で温度変化や湿度変化によるずれを抑制することができ、書き換え時の画像ずれを防いで鮮明な画像を形成することができる。

【００７４】請求項１２の発明によれば、画像表示層の透明支持体の上から磁気粒子を回転可能な磁気ペンを用いることにより、手書きで任意に画像を追加したり、消去したりすることができる。

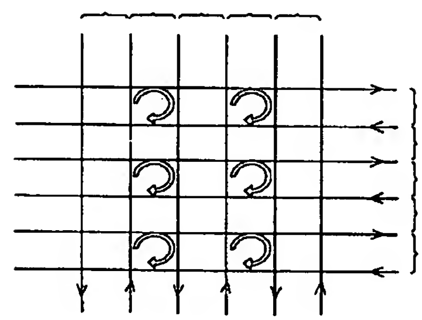
【図面の簡単な説明】
【図１】本発明の一実施の形態の磁気粒子回転型表示素子を示す断面図である。
【図２】本発明にかかる電気配線による磁界発生方法を

説明する図である。
【図３】本発明にかかる電気配線による磁界発生方法を説明する図である。
【図４】従来技術のＭＰＤの構成例を示す図である。
【符号の説明】
１……回転粒子
２、１３……回転粒子層
３、２１……電気配線層
４、１５……メモリー層
６……マイクロカプセル
１１、１６、１７、２２……支持体
１２……磁気粒子
１４、１９、２０……保護膜
１８ａ、１８ｂ……電気配線

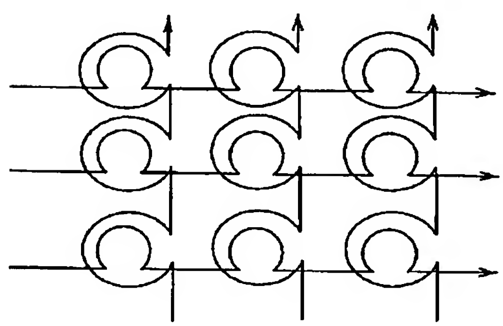
【図１】



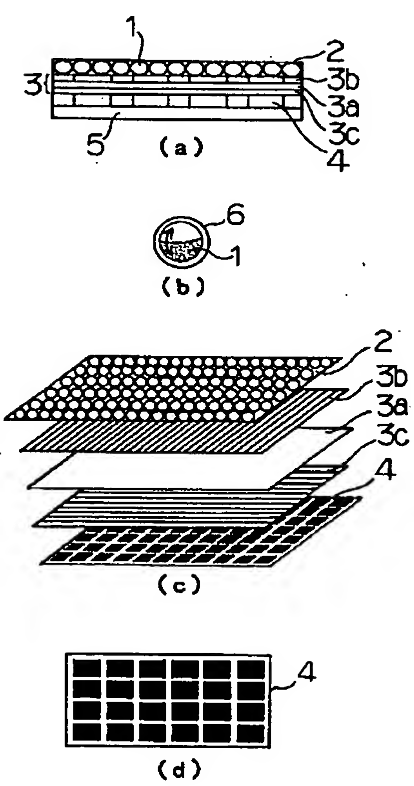
【図２】



【図３】



【図４】



CLAIMS

[Claim(s)]
[Claim 1] The image display layer in which the magnetic particle which was classified by color possible [a color substitute] by rotation, and was magnetized is arranged pivotable on a transparence base material, The electric wiring layer which generates the field which rotates said magnetic particle per pixel of said image display layer, The magnetic particle rotation mold display device characterized by providing the memory layer which has the perpendicular magnetic anisotropy which is inserted between said image display layers and electric wiring layers, is magnetized by said electric wiring layer, and gives a field to the magnetic particle of said image display layer.
[Claim 2] The magnetic particle rotation mold display device characterized by being in the range whose mean particle diameter of said magnetic particle is 5 micrometers - 30 micrometers in a magnetic particle rotation mold display device according to claim 1.
[Claim 3] The magnetic particle rotation mold display device characterized by enclosing said magnetic particle with the lubricative liquid pivotable in a transparent microcapsule in a magnetic particle rotation mold display device according to claim 1.
[Claim 4] The magnetic particle rotation mold display device characterized by enclosing said magnetic particle into the hole regularly prepared in the plate of transparence in a magnetic particle rotation mold display device according to claim 1.
[Claim 5] The magnetic particle rotation mold display device which said magnetic particle is classified by semi-sphere every 2 colors by color, and is characterized by one color being white in a magnetic particle rotation mold display device according to claim 1.
[Claim 6] The magnetic particle rotation mold display device characterized by said magnetic particle containing nitriding iron in a magnetic particle rotation mold display device according to claim 1.
[Claim 7] The magnetic particle rotation mold display device characterized by having the circuit pattern layer of the pair by which conductive wiring was prepared in parallel in the direction in which said electric wiring layer intersects perpendicularly mutually through an insulating layer in the pixel pitch in the magnetic particle rotation mold display device according to claim 1, respectively.
[Claim 8] The magnetic particle rotation mold display device characterized by being controlled so that the current of parallel conductive wiring with which said electric wiring layer adjoins each other flows to hard flow mutually in a magnetic particle rotation mold display device according to claim 7.
[Claim 9] The magnetic particle rotation mold display device characterized by having a coil configuration to which the character of KO laps with the part to which each conductive wiring crosses through said insulating layer while coming to prepare conductive wiring in a pixel pitch in the direction in which said electric wiring layer intersects perpendicularly mutually through an insulating layer in a magnetic particle rotation mold display device according to claim 1, respectively.
[Claim 10] The magnetic particle rotation mold display device characterized by forming the antireflection film in the transparence base material of said image display layer in a magnetic

particle rotation mold display device according to claim 1.
[Claim 11] The magnetic particle rotation mold display device characterized by the transparence base material of said image display layer and the base material of said electric wiring layer consisting of same ingredients in a magnetic particle rotation mold display device according to claim 1.
[Claim 12] The magnetic particle rotation mold display device characterized by providing the magnetic pen which generates the field which rotates said magnetic particle from on the transparence base material of said image display layer in a magnetic particle rotation mold display device according to claim 1.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the magnetic particle rotation mold display device which the optical condition on the front face of a particle changes with rotations of the particle which consists of the magnetic substance, and displays images, such as a graphic form and an alphabetic character.
[0002]
[Description of the Prior Art] MPD (magnetic particle display) which rotates a particle by the field was proposed by Magnavox in 1975 (L. L.Lee:IEEE Transaction on Electron Devices, ED-22, P758). The magnetic-substance spherical particle which white and the remaining semi-sphere side were colored for the semi-sphere side black was used for this MPD. Then, each particle is microencapsulated and it is improved by the approach of covering a transparence sheet with this.
[0003] As drawing 4 shows the example of a configuration of Above MPD and shows it to (a), the laminating of the substrate 5 is carried out to the rotation particle layer 2 which displays an image with the surface color of the rotation particle 1 sequentially from a top, the electric wiring layer 3 which has a field generating function, and the memory layer 4 which is magnetized by the electric wiring layer 3 and gives rotating magnetic field to the rotation particle layer 2. Endocyst is carried out to a microcapsule 6 and the rotation particle 1 which becomes the rotation particle layer 2 from the magnetic substance of the iron oxide classified by black and white by color is arranged, as shown in drawing 4 (b). As shown in both sides of base material 3a which consist of polyimide at drawing 4 (c), the copper wiring 3b and 3c is spread around in the shape of an X-Y matrix, and the electric wiring layer 3 is constituted, and reverses the magnetization direction of the magnetic layer of the part equivalent to the pixel section by the magnetic field of the field surrounded by two X each Rhine and Y lines. The memory layer 4 consists of a magnetic layer with a thickness of several mm, and it is divided into the prism of a pixel unit in the shape of a grid that magnetic shape anisotropy should be used so that it may expand to drawing 4 (d) and may be shown, and a field can be perpendicularly impressed to the rotation particle layer 2. This pixel size of MPD is 0.5-1.7mm, and the rotation particle with a particle diameter of 30-400 micrometers was used.
[0004]
[Problem(s) to be Solved by the Invention] By the way, there were the following troubles in Above MPD.
** Although the particle of a rotation particle layer was slowly rotated by the field of a memory layer after magnetizing a memory layer first at high speed by the generating field of an electric wiring layer, with the configuration of a rotation particle layer / electric wiring layer / memory layer, since the memory layer which gives rotating magnetic field is separated with the rotation particle layer, it is hard to tell the field of a memory layer, and dispersion arises in particle rotation, and it was hard to obtain a clear image.
[0005] ** Since it was separated with the rotation particle layer, big record magnetic field strength was required for the memory layer, and in order to obtain record magnetic field strength

with the big memory layer of a thick film, it needed to enlarge the generating field of an electric wiring layer.
** since the particle diameter of a rotation particle is as large as 30 micrometers or more -- an image -- resolution was low.
** Although the memory layer was formed in the shape of a grid, since production of such a complicated configuration was difficult, its production cost was high.
[0006] By this invention having coped with the trouble of the above-mentioned conventional technique, having been made, and making a memory layer an easy configuration thinly, and approaching a rotation particle layer and preparing, manufacture is easy and it aims at offering a low power and the magnetic particle rotation mold display device of a high resolution.
[0007]
[Means for Solving the Problem] Namely, the image display layer in which the magnetic particle which invention of claim 1 was classified by color possible [a color substitute] by rotation, and was magnetized is arranged pivotable on a transparence base material, The electric wiring layer which generates the field which rotates said magnetic particle per pixel of said image display layer, It is the magnetic particle rotation mold display device characterized by providing the memory layer which has the perpendicular magnetic anisotropy which is inserted between said image display layers and electric wiring layers, is magnetized by said electric wiring layer, and gives a field to the magnetic particle of said image display layer.
[0008] In invention of claim 1, if the current controlled by the electric wiring layer based on the picture signal flows and the field of the pixel unit corresponding to a picture signal occurs, it will be magnetized per pixel and a memory layer will give the field of the pixel unit corresponding to a picture signal to the magnetic particle of an image display layer. Thereby, each magnetic particle of an image display layer is controlled by the rotation condition corresponding to a picture signal, and an image is formed of the color which each magnetic particle turned to the transparence base material side. The image by rotation of each of this magnetic particle is held by the memory layer until the following field occurs by the electric wiring layer. While becoming possible by a memory layer approaching an image display layer, and it being prepared, and having a perpendicular magnetic anisotropy here to form with a thin film, without forming a memory layer in the prism of a pixel unit, record magnetic field strength is small, and it ends, and is attained, reduction-izing, i.e., power-saving, of a current which flows in an electric wiring layer.
[0009] Invention of claim 2 is characterized by being in the range whose mean particle diameter of a magnetic particle is 5 micrometers - 30 micrometers in the magnetic particle rotation mold MAG display device of claim 1. By setting mean particle diameter of a magnetic particle to 30 micrometers or less, pixel size can be set to 126 micrometers or less, and it becomes possible to obtain 200 or more dpi and a high-resolution image. Moreover, if particle diameter is set to 5 micrometers or less, the magnetization per piece will become small and rotation by the field will become difficult.
[0010] Invention of claim 3 is characterized by enclosing the magnetic particle with the lubricative liquid pivotable in a transparent microcapsule in the magnetic particle rotation mold MAG display device of claim 1. In this invention, it is endocyst's being carried out to a microcapsule and arranged on a transparence base material, and by the field, rotation of a magnetic particle is attained and the clear image formation of it becomes possible.
[0011] Invention of claim 4 is characterized by enclosing the magnetic particle into the hole regularly prepared in the plate of transparence in the magnetic particle rotation mold MAG display device of claim 1. In this invention, it is that a magnetic particle is enclosed into the hole prepared regularly, it becomes easy to arrange a magnetic particle more regularly, while rotation becomes free by the field like the condition that endocyst was carried out to the microcapsule, and an image with high resolution is obtained.
[0012] In the magnetic particle rotation mold MAG display device of claim 1, a magnetic particle is classified by semi-sphere every 2 colors by color, and invention of claim 5 is characterized by one color being white. A monochrome image is displayed when all the magnetic particles arranged by the image display layer are classified by black and white by color. A color picture is displayed, when two or more colors are used combining white and it is arranged by the image display layer.

[0013] Invention of claim 6 is characterized by a magnetic particle containing nitriding iron in the magnetic particle rotation mold MAG display device of claim 1. In this invention, it is using the big nitriding iron of saturation magnetization for the magnetic substance of a magnetic particle, and big running torque is obtained and it becomes possible with few current values, the roll control, i.e., the image formation, of a magnetic particle.
[0014] Invention of claim 7 is characterized by having the circuit pattern layer of the pair by which conductive wiring was prepared in parallel in the direction in which an electric wiring layer intersects perpendicularly mutually through an insulating layer in the pixel pitch, respectively in the magnetic particle rotation mold MAG display device of claim 1. In this invention, while being preparing in the shape of a high grid so that a circuit pattern's may not be mutually touched in the direction of X, and the direction of Y and becoming possible to generate a field per pixel, production of an electric wiring layer is easy and a cheap display device is obtained.
[0015] Invention of claim 8 is characterized by being controlled so that the current of parallel conductive wiring with which an electric wiring layer adjoins each other flows to hard flow mutually in the magnetic particle rotation mold MAG display device of claim 7. In this invention, since the big rotating magnetic field at the core of the grid formed with the circuit pattern of the direction of X and the direction of Y are obtained, it becomes possible with few current values, the roll control, i.e., the image formation, of a magnetic particle.
[0016] In the magnetic particle rotation mold display device of claim 1, invention of claim 9 is characterized by having a coil configuration to which the character of KO laps with the part to which each conductive wiring crosses through an insulating layer while coming to prepare conductive wiring in a pixel pitch in the direction in which an electric wiring layer intersects perpendicularly mutually through an insulating layer, respectively. In this invention, since the big rotating magnetic field at the core of the character of KO of a part that conductive wiring crosses through an insulating layer are obtained, it becomes possible with few current values, the roll control, i.e., the image formation, of a magnetic particle.
[0017] Invention of claim 10 is characterized by forming the antireflection film in the transparence base material of an image display layer in the magnetic particle rotation mold display device of claim 1. In this invention, the color tone of a magnetic particle becomes clearer, a flicker of an image is controlled, and a clearer image is obtained.
[0018] Invention of claim 11 is characterized by the transparence base material of an image display layer and the base material of an electric wiring layer consisting of same ingredients in the magnetic particle rotation mold display device of claim 1. In this invention, the gap by telescopic motion of the base material accompanying a temperature change or humidity is controlled between an image display layer and an electric wiring layer, the image gap at the time of rewriting is prevented, and clear image formation becomes possible.
[0019] Invention of claim 12 is characterized by providing the magnetic pen which generates the field which rotates a magnetic particle from on the transparence base material of an image display layer in the magnetic particle rotation mold display device of claim 1. In this invention, it becomes possible to add an image to arbitration with a magnetic pen, or to eliminate from on a transparence base material.
[0020]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained based on a drawing. Drawing 1 is the sectional view showing the gestalt of 1 operation of the magnetic particle rotation mold display device of this invention. In this drawing, the magnetic particle 12 by which two or more color usual was classified by color in two colors is arranged by the base material 11 of transparence pivotable from the surface observation side. Sequential arrangement of the electric wiring layer 21 by which the memory layer 15 and base material 16 with which the protective coat 14 was formed were arranged, pattern formation of the electric wiring 18a and 18b was carried out to both sides of the base material 17 which serves as an insulating layer further, and protective coats 19 and 20 were formed in this rotation particle layer 13, and the base material 22 is carried out. Moreover, an antireflection film (not shown) is prepared in the base material 11 of the rotation particle layer 13 if needed.
[0021] The magnetic particle 12 contains the magnetic substance, it is magnetized so that it

might be classified by two colors by color, while N pole and another side may become the south pole in them, and it serves as a permanent magnet. As a magnetic particle 12, the mixture of the ultrafine particle of the magnetic substance and polymers, such as polyethylene and phenol resin, is used. Moreover, a magnetic-substance independent particle may be used. In this case, magnetization becomes strong rather than mixture with a polymer, therefore the torque for rotation becomes strong. For this reason, since the magnetic field strength which rotation takes is small, it ends and the current value of the electric wiring layer 21 can be reduced, power-saving can be attained. Although an ellipse and a polygon are sufficient as the configuration of the magnetic particle 12, in order to rotate smoothly, its globular form is desirable.
[0022] The particle diameter of the magnetic particle 12 has desirable 30 micrometers or less. Although the rotation particle with a particle size of 30 micrometers or more was used in MPD of the conventional technique, when it is going to obtain 200 or more dpi and a high-resolution image, this is because it was the magnitude whose pixel size is 0.5-1.7mm, pixel size is set to 126 micrometers or less, the particle size of a magnetic particle is too large in 30 micrometers or more, and sufficient resolution is not obtained. On the other hand, if particle diameter is not much small, the magnetization per piece will become small and rotation of it by the field will become impossible. Moreover, rotation functional grant processing, for example, microencapsulation etc., becomes difficult. Although based also on the saturation magnetization of the magnetic substance used for the magnetic particle 12, 5 micrometers or more are desirable.
[0023] Moreover, since magnetization will become small if the particle size of the magnetic substance becomes small, as the magnetic substance, the larger one of saturation magnetization becomes large and is desirable [running torque]. Saturation magnetization is as large as 120 - 140 emu/g twice [about], and the iron oxide (gamma-Fe 2O3 and Fe 3O4) of nitriding iron (Fe4 N) generally used is desirable, although saturation magnetization is 70 - 80 emu/g.
[0024] Although coercive force of the magnetic substance is the half-hard magnetism object or hard magnetism object of 50 or more Oes and the color is generally black, other colors, such as yellow, and brown or green, are sufficient. As the black magnetic substance, there are various ferrites, such as Fe, Co, nickel, Fe 2O3, Fe 3O4, Co ferrite, and a MnZn ferrite. What is necessary is to color only a semi-sphere white, if the magnetic substance is black although the color of the magnetic particle 12 is usually classified by two colors of white and black by color a semi-sphere every. The background color is chosen instead of white to carry out the color of a background in addition to white. The so-called coloring of red (R), green (G), blue (B), etc. in three primary colors is performed with white to obtain a color picture. Three or more colors may be colored depending on the case. For example, FURUKARA can be displayed if it has classified by color in five colors of the above-mentioned white and black. As a particle coloring matter in three primary colors, colors, such as a methylene blue, Congo Red, and the benzoyellow TZ, oil blue, oil cleanness, oil yellow, benzidine yellow, etc. are used. Moreover, the color tone of the magnetic particle 12 can check now more clearly by preparing an antireflection film on the rotation particle layer 13 in which the magnetic particle 12 was arranged.
[0025] In order to color white one side of black and each color particle of R, G, and B, there is the approach of putting the aluminum film using vacuum deposition methods, such as a coating method and a spray method, although many things are considered, after forming a particle further and fixing as easiest approach. Although the aluminum film has metallic luster, if it becomes the particle of the diameter of 5-30 micrometer, this metallic luster will no longer be sensed and will be observed as the so-called white. The front face of the magnetic particle 12 classified by color may be thinly coated with the organic substance or an inorganic substance, in order to decrease surface irregularity, or in order to raise surface lubricity.
[0026] A rotation function is given to the magnetic particle 12 which was colored as mentioned above and magnetized, and it is arranged on a base material 11. Although there are some approaches of giving a rotation function, the approach of enclosing the magnetic particle 12 with a transparent microcapsule as one is mentioned. independent [in common resin, such as acrylic, an methacrylic system, polyester, polystyrene, poly urea, a polyamide, and epoxy,] as an ingredient which constitutes the outer shell of a microcapsule -- or it can be mixed and used.

in-situ which supplies a monomer as the manufacture approach of a microcapsule from one side of the internal phase of an emulsion or external phase who distributed the interfacial polymerization which supplies both the inside of an emulsion, and an outside to the monomer which distributed the magnetic particle, and a magnetic particle -- law and other well-known microencapsulation techniques are used. Properties, such as a certain amount of [the outer shell of a microcapsule] mechanical strength which pushes and bears **, transparency, and chemical stability, are searched for. Moreover, a lubrication action for the fluid made to contain in a microcapsule to make rotation of the magnetic particle 12 smooth is called for most, and liquids, such as water, an oil, and alcohol, are used.
[0027] The magnetic particle 12 to which the rotation function was given is arranged on the transparent base material 11. Although it is desirable to arrange various ****s and the same size particle only one layer regularly also to this array approach, about 1.5 layers or two sorts of size particles may be arranged to a multilayer. As a transparence base material, transparence resin, such as MMA (methyl methacrylate), PMMA (polymethylmethacrylate), a polycarbonate, polypropylene, acrylic resin, styrene resin, ABS plastics, polyarylate, Pori Sall John, a polyether ape phon, an epoxy resin, the Polly 4-methyl pentene -1, fluorination polyimide, a fluororesin, phenoxy resin, polyolefine system resin, and Nylon, is used.
[0028] There is a method of making a particle enclose into the hole regularly prepared in the plate made of a transparent plastic as an approach in the case of arranging the same size particle only one layer regularly. It is the size into which the height of a hole can rotate one particle and, as for length and width, plurality goes. In this case, the microcapsule which gives a rotation function to the magnetic particle 12 does not have the need. It becomes instead of the hole of a transparence plastic sheet being a microcapsule. It is still better if the liquid for frictional resistance reduction (for example, oil) is enclosed into this hole. Since the advantage of this approach can arrange a particle regularly, it is that a high quality picture is obtained. In addition, as for this approach, it is needless to say that it can arrange also at random.
[0029] As an approach of forming a hole, the following approaches are in this transparence plastic sheet (J Vac Sci Technol B Vol.16, No.6 p.3825-3829, 1998 reference).
1. For example, prepare on a silicon wafer, the metal, for example, Pt layer, for electroplating.
2. It is SiO2 with a CVD method etc. on this. The film is made. It is ****** about the depth of the hole into which this thickness puts a particle.
3. Prepare PMMA with a spin coat method etc. as a transparent plastic on this.
4. Expose a hole pattern on PMMA with lithography.
5. Prepare Cr with vacuum deposition etc. on PMMA.
6. Form a hole in PMMA and Cr layer by reactive ion etching.
[0030] Unlike the conventional MPD, the memory layer 15 is formed in contact with the rotation particle layer 13. Moreover, the memory layer 15 consists of a magnetic layer which has a perpendicular magnetic anisotropy, and is formed in uniform thickness. That is, the perpendicular magnetic anisotropy films 2 or more KOes of whose perpendicular magnetic-anisotropy constants Hk are 4 or more KOes preferably are used as a memory layer 15. Since a big generating field is acquired by the perpendicular direction of a memory stratification plane rather than the case of the magnetization film within a field of the same thickness by using these perpendicular magnetic anisotropy films, a memory layer can be made thin more.
[0031] The memory layer 15 has the function to hold the rotation condition and to prevent turbulence of an image while supporting rotation of the magnetic particle 12 of the rotation particle layer 13 by the field of the memory layer 15 which was magnetized by the field generated by the electric wiring layer 21, and was magnetized further. That is, although the direction of a generating field of the electric wiring layer 21 is changed by making the direction of a current reverse, it magnetizes the specified location corresponding to the pixel of the memory layer 15 to + or - according to this generated direction of a field. Every pixel is sufficient as this magnetization, and every two or more pixels are sufficient as it. Since speed of this 1-pixel magnetization can be carried out at 1 or less microsecond and a high speed, it is possible to the order of a second also at a big screen, for example like A4 size. When this memory layer 15 does not exist, it is necessary to rotate the magnetic particle 12 by the field of the electric wiring

layer 21 for every particle. even if magnetic particle rotation is quick -- 20 -- since it takes about m seconds, in A4 size, it will cut in long duration. There are various the field impression approaches by the electric wiring layer 21, if the approach of impressing [two or more] to coincidence every is used, an image will be obtained quickly, but if the number of pixels impressed to coincidence increases, the current value which flows to coincidence will also increase indeed. Since it is difficult practically to pass the current more than 1A in respect of equipment size etc., the memory layer 15 is indispensable in order to obtain an image at high speed.
[0032] Moreover, it is necessary to fix the rotated magnetic particle 12 to re-rewriting at the time of the next roll control so that an image may not change. Also in this case, since magnetization of the memory layer 15 does not change with time amount by forming the memory layer 15, the magnetic particle 12 which is a permanent magnet is fixed, with the same direction turned to. In addition, as an approach of fixing the magnetic particle 12 after rotation, there is also an approach using the thixotropy liquid with which resistance increases after rotating between the magnetic particle 12 and resin layers, such as a microcapsule, besides installation of the memory layer 15.
[0033] By the way, in order to rotate the magnetic particle 12, it is required to give attraction and repulsive force to magnetization of the particle which was made to generate a field at right angles to the field of this display device, and was permanent-magnet-ized. Although it enables it to impress a field to a direction for the magnetic material which has plane anisotropy perpendicularly as a long configuration in MPD of the conventional technique using magnetic shape anisotropy, with the gestalt of this operation, a perpendicular magnetic anisotropy is given to memory layer 15 the very thing, and a particle is rotated by the field perpendicularly generated in a display device side. By using these perpendicular magnetic anisotropy films, it is not necessary to process the magnetic substance in the shape of a column for every pixel, since processing of a uniform layer is sufficient, manufacture can become easy, therefore cost can be reduced sharply.
[0034] As an approach of creating the perpendicular magnetic anisotropy films which have a perpendicular magnetic anisotropy, a hexagon-head plate is put in order, the coating of the magnetic-substance powder which has a hexagon-head tabular configuration like a barium ferrite, for example is applied in parallel with a substrate side, impressing a magnetic field, (orientation), and there is the approach of creating perpendicular magnetic anisotropy films. Between rolls of the mixture of a barium ferrite and resin is passed similarly, and there is also the approach of. carrying out orientation of each particle and producing in the shape of sheet metal. Moreover, there is the approach of producing on a substrate metallic compounds, such as TbFeCo widely used as magneto-optic-recording material media, by PVD, such as a spatter. There are also an approach of producing with plating the ingredient which otherwise has perpendicular magnetic anisotropies, such as PtCo, and the approach of producing with a sol-gel method. Neither an ingredient nor the production approach is limited in this invention. With an ingredient with sufficient stability, it is more thin and the approach of being easy to make is selected.
[0035] Next, the electric wiring layer 21 used for magnetization of the memory layer 15 is explained. a current flows to electric wiring 18a and 18b -- the magnetic particle 12 can be rotated within a microcapsule by the interaction (attraction or repulsive force) of the residual magnetization of the magnetic field to generate and each magnetic particle 12. Since magnetic field strength required for rotation is small good at about 10 gauss, electric wiring 18a and 18b is possible by the approach of wiring so that it may prepare in X and the direction of Y in the shape of a straight line, respectively and the grid of each other may be formed. In this case, there is an advantage that a wiring configuration is simple and production is easy. Two main tracks are used as one pair, respectively, a current is passed to hard flow in two main tracks, and you may make it make the target pixel generate a field in the direction of X, and the direction of Y in that case, as shown in drawing 2 .
[0036] Out of this, electric wiring 18a and 18b may be made to correspond to each pixel at each single track of X and the direction of Y, as shown in drawing 3 , and a horseshoe-shaped coil may be prepared, and you may form so that the coil of that one turn may lap through an

insulating layer in X and the direction of Y. If the coil of 2 or more ******s is prepared, of course corresponding to each pixel location, a current value required for excitation is small, and it ends, and although it is desirable, it will be necessary to become unproducible at a monolayer, and wiring will need to consist of multilayers which include an insulating layer in the middle. Moreover, it becomes difficult to double an up-and-down wiring location. In addition, the generating strong magnetic field by electric wiring and the location of a pixel are produced so that it may be in agreement.

[0037] electric wiring 18a and 18b -- the above -- also in which wiring approach, the field has occurred besides the target pixel section, and a threshold is required for the force required for rotation of the magnetic particle 12 so that it may be pivotable in the magnetic particle 12 only in the target pixel section. Such a threshold is controlled by viscosity of a microcapsule and the liquid between magnetic particles etc. Viscosity control material, such as sodium alginate, polyvinyl alcohol, denaturation sodium polyacrylate, a denaturation polyacrylic acid emulsion, and a denaturation polyacrylic acid sulfonate, is used for the viscosity control of such a liquid. Especially, sodium alginate and polyvinyl alcohol are desirable.

[0038] Moreover, also in which wiring approach, electric wiring 18a and 18b can form a copper layer in the flesh side of insulating layers, such as a polyimide film, and both sides of a table with vacuum deposition, a spatter, plating, etc., and can form it by etching this copper layer except for a circuit pattern. Besides this photolithography method, a replica method can be used and a circuit pattern can also be formed. For example, it patternizes after forming a resist on 1. conductivity substrate. 2. Prepare a metal, for example, copper, by the electroplating method on this. 3. Make adhesives adhere with plating on this. 4. Turn this adhesive coated surface down, for example, imprint on a plastic plate, and form electric wiring. This replica method can respond to a large area easily by low cost, and it has the advantage that creation of super-thin wiring or solid wiring is easy. In addition, although the common copper of the ingredient used for electric wiring is desirable from the point of an electric resistance value, the conductive ingredient of others, such as Au, Ag, aluminum, and Pt, is also used. Moreover, the common ITO film as transparence electric conduction film may be used.

[0039] Moreover, in order to prevent the damage on a blemish, exfoliation, etc., as signs 14, 19, and 20 show to drawing 1 It is desirable from the point of the endurance of a device to prepare a protective coat. SnS, aluminum2 O3 / [SiO, SiO2, ITO, ZrC, TiC and MgF2, MgO, BeO and ZrO2, Y2 O3, aluminum 2O3, and] Ta 2O5; SiAlON, AlN, Si3 N4, SiCN:H, etc. are used. As an organic resin protective coat, the photo-setting resin constituent and heat photo-setting resin constituent which use a polymerization nature monomer and oligomer as a principal component can be used. 50-1000nm of thickness is desirable.

[0040] It not only forms by the above-mentioned electric wiring layer 21, but the image of the rotation particle layer 13 can be formed again from the side which looks at, the opposite side, i.e., the image, of a base material 11. For example, it is also possible to carry out image formation with the magnetic pen which established the iron core into the coil and was used as the nib. When it can write in only at the time of energization of a certain direction and energizes in the direction contrary to this, the nib is possible in combination with a magnetization setup of the magnetic particle 12 so that an image can be erased. Although it is necessary to reverse a tip mechanically and inconvenient when a thin cylinder-like permanent magnet is used as a nib, when an electromagnet is used, the direction of a field can be easily reversed by button grabbing.

[0041] In addition, when a field occurs in the pixel section, migration, i.e., postscript actuation, of a magnetic pen, a current flows in the electric wiring layer 21. If the current detector which detects this current is arranged at each wiring edge, even if it does not arrange image sensing elements, such as a touch panel, specially, a postscript image is easily recordable on a display and coincidence by low cost.

[0042] As stated above, the color picture of the magnetic particle 12 also becomes possible not only black and white but by controlling particle rotation by the magnetic field generated by the electric wiring layer 21, since it can be further colored **** of R, G, and B. In this case, the magnetic particle 12 colored by each color of black and white and RGB can also change and

arrange coercive force and magnetic classes (antiferromagnetism etc.).
[0043] Moreover, the base material 11 which is a clear layer having protection of a component front face and the function of a base material is formed in a display device maximum front face. It will let this base material 11 pass, and the image contrast made by the magnetic particle 12 will be observed. In this case, the light reflected by the front-face side of a base material 11 becomes the factor which disturbs an image. Therefore, a clearer image can be obtained by preparing the antireflection film for preventing this reflected light generating. The stable matter is thermally [transparently / the ingredient used for an antireflection film] suitable. For example, the oxide of a metal or semimetal, a nitride, a chalcogen ghost, a hooker object, They are carbide and such mixture. Specifically SiO2, SiO, aluminum 2O3, GeO2, In 2O3, Ta 2O5, and TeO2, They are simple substances or these multilayers, such as TiO2, MoO3, WO3, ZrO2, Si3 N4, AlN, BN, TiN, ZnS and CdS, CdSe, ZnSe, ZnTe, AgF and PbF2, MnF2, NiF2, and SiC. Each thickness is preferably good to make [5-200nm] it the range of 5-30nm. The film is formed using various kinds of PVD(s) and a CVD method.
[0044] Moreover, plastic material is used for the transparent base material 11 with which the rotation particle layer 13 is formed, and the base material 17 in which the electric wiring layer 21 is formed. Although this is for being light and making the whole display device thin, the telescopic motion of plastic material by heat or humidity is large. As for the image displayed once, a pixel location shifts in response to the effect of temperature or humidity. This gap becomes so large that it becomes a big screen. If it differs from the pixel location of the electric wiring layer 21 of a basis when displaying a new image on the same display device, the image part which cannot be overwritten will be generated. Therefore, since it writes in with the rotation particle layer 13 which is a display layer and the gap by temperature or humidity is not produced between the electric wiring layers 21 which are layers, it is desirable to use the same plastic material for the base material 11 of the rotation particle layer 13 and the base material 17 of the electric wiring layer 21. By this, it comes at the time of image rewriting to prevent the image gap by telescopic motion of a base material arising, and generating of the image by the electric wiring layer 21 which is not rewritable can be suppressed as much as possible.
[0045] In the gestalt of this operation, it is a light weight and a thin shape, and without destroying, even if deformation of some occurs, high definition image formation is possible at power saving, and a postscript can also obtain a possible magnetic particle rotation mold display device from on an image so that clearly also from the above-mentioned explanation. Although especially the memory layer was conventionally pillar-shaped and component thickness was thick, it became possible to make the whole equipment light thinly by using the thin film which has a perpendicular magnetic anisotropy. Moreover, 100mA or less of current values of the electric wiring layer which magnetizes a memory layer by approaching a rotation particle layer and installing the memory layer which supports magnetic particle rotation since magnetic particle rotation is possible at the magnetic field strength of several gauss usually became possible [a next door and displaying an image with a precision more sufficient at power saving] enough by 10mA or less at the maximum.
[0046]
[Example] Hereafter, the example of this invention is explained.
Fe 3O4 whose example 1 mean particle diameter is 0.2 micrometers The ultrafine particle was distributed to the polyethylene solution. It was heated by about 100 degrees C and the circumference edge under rotation trickled these dispersion liquid into the tooth form-like disk by 30000RPM. It quenched the particle which collided with this rotating disk and dispersed, and it became round the shape of a true ball so that surface energy might be lowered. Uptake of this particle was carried out to the drum, and Fe3 O4 / polyethylene mixing (it is 1/1 at volume ratio) black particle whose mean particle diameter is 15 micrometers and whose maximum particle diameter is 30 micrometers were obtained.
[0047] After sprinkling the mixed globular form particle near this true ball so that it may become only one layer on a commercial pressure sensitive adhesive sheet, the opening was further filled up with the particle and it fixed. The vacuum deposition method was used on this fixed particle, and the aluminum thin film was formed in the thickness of about 100nm. The aluminum film is

formed in the upper half (about 50% of white area) of a mixed particle, and is not put on a lower half. The particle on a sheet was observable in not a metallic color but the so-called white for the particle. The coercive force measured by VSM (oscillating sample mold magnetometer) was 108Oe(s), and residual magnetization was 67 emu/g. This particle firmly attached seat has been arranged between the pole piece of an electromagnet as it is, and it was magnetized so that the direction of the line which impresses a 100 gauss field and connects white and a black core, and magnetization might gather. Subsequently, each magnetic particle was exfoliated from the sheet.
[0048] The above-mentioned magnetic particle was put into the 55-degree C gelatin water solution, and was agitated. Gum arabic was added to this solution, it was made acidity, solution temperature was further lowered [PH was lowered,] to 20 degrees C or less, the polymer film of gelatin/gum arabic was generated and hardened, and the microcapsule was formed. This microcapsule is immersed into a silicone oil, a silicone oil is infiltrated between a microcapsule and a magnetic particle, and it enabled it to rotate a magnetic particle within a capsule. The monochrome color has been checked through the microcapsule.
[0049] Next, the antireflection film of MgO with a thickness of 100nm was prepared in one side of a polycarbonate substrate with a thickness of 100 micrometers with vacuum evaporation technique, and it was coated with ultraviolet-rays hardening resin in another field. The water solution of the microcapsule which carried out [above-mentioned] production was hung down to the ultraviolet-rays hardening resin spreading side of a polycarbonate substrate, and vibration was added so that a microcapsule might arrange by the thickness of only one layer. Then, irradiate ultraviolet-rays hardening resin, it was made to harden UV light, each microcapsule location was fixed, and the image display section was produced.
[0050] Next, perpendicular magnetic anisotropy films with a thickness of 0.5 micrometers were formed on the polycarbonate film with a thickness of 20 micrometers using the spatter by using TbFeCo as a target. The coercive force which impressed and measured the perpendicular direction field was 180Oe(s). Perpendicular anisotropy fields were 4.5KOe(s). The protective coat of SiN with a thickness of 100nm was similarly formed using the spatter on this film. Thus, on the protective coat of the produced memory layer, adhesives were used, and the polycarbonate substrate of said image display section was ****ed outside, and was stuck in piles.
[0051] Next, after preparing nickel film of 10nm thickness in one side of a polycarbonate substrate with a thickness of 100 micrometers by the spatter, the copper film of 5-micrometer thickness was formed with plating. Patterning of this copper film was carried out by the photolithography method, and copper wiring was formed by the etching method. The circuit pattern was made into the coiled form of 3 turns. Moreover, the pitch between coils (i.e., between pixels) was set to 127 micrometers (200dpi). Then, the SiN film of about 100nm thickness was further prepared as a protective layer on the circuit pattern by the spatter. A drive circuit which a field with a coil generates one [at a time] one by one at the intersection of wiring of X and the direction of Y was established in each wiring edge. After uniting in piles the electric wiring layer produced as mentioned above with the lamination article of the image display section which arranged the microcapsule, and a memory layer like drawing 1 , the seal of the edge was carried out by resin, and the display device was produced.
[0052] Subsequently, the drive circuit was used for each electric wiring, and the current was passed one by one. The current controlled the direction with the magnetic pole of the magnetic particle on each coil (pixel) to oppose. It rotated and the magnetic particle showed black. Each pixel was able to be made to have been able to produce the migration to black and white similarly, contrast was able to be acquired, and monochrome image was able to be obtained. The image could be clear, without flickering and being visible with the reflected light in the front face of a transparence base material, and was able to indicate by the repeat. Moreover, the irregularity of a magnetic particle was not worried. The formed image did not disappear semipermanently until it rewrote it.
[0053] Furthermore, the coil was formed in the iron bar with a diameter [of 0.8mm], and a die length of 15mm, and it considered as the electromagnet, and with a cell and a switch, as the current flowed in the both directions of positive/negative, the magnetic pen for field generating in which an image can be entered from on the transparence base material of the image display

section was produced. After passing and carrying out image formation of the current to the electric wiring layer of the above-mentioned display device, the current was passed in the forward direction on this magnetic pen, the pen was run from on the transparence base material, and the image was eliminated. Moreover, the current was passed in the negative direction and the line drawing image was newly added. Since the polycarbonate substrate of the same ingredient was used for the transparence base material of the image display section, and the base material of an electric wiring layer, there were few parts which were not able to carry out image rewriting, and the image was clear.

[0054] It sets in the example 2 example 1, and is Fe 3O4 with a mean particle diameter of 15 micrometers as a magnetic particle instead of Fe3 O4 / polyethylene mixing particle. The thickness of a microcapsule was made to double [about] in order to prevent with [which goes away between magnetic particles] ** using a black magnetic-substance particle. Others produced the display device like the example 1. The image which passed and acquired the current to electric wiring was clear. Moreover, from the magnetic rotation particle of an example 1, in spite of increase of the part to which saturation magnetization increased twice [about], and particle weight, particle running torque was able to increase, rotation was able to become possible with fewer current values, and power-saving was able to be attained.

[0055] It sets in the example 3 example 1, and is Fe 3O4 with a mean particle diameter of 0.2 micrometers. The black magnetic-substance particle of Fe4 N with a mean particle diameter of 0.2 micrometers was used instead of the ultrafine particle, and the mixed particle of Fe4 N / polyethylene was produced as a magnetic particle. Moreover, the thickness of a microcapsule was made to double [about] in order to prevent with [which goes away between magnetic particles] **. The image which others produced the display device like the example 1, and passed and acquired the current to electric wiring was clear. Moreover, from the magnetic rotation particle of an example 1, the part and particle running torque to which saturation magnetization increased twice [about] were able to increase, rotation was able to become possible with fewer current values, and power-saving was able to be attained.

[0056] On both sides of the polycarbonate substrate of 4100 micrometer thickness of examples, the copper film of 5-micrometer thickness was produced with vacuum evaporation technique, patterning of this copper film was carried out by the photolithography method, and copper wiring was formed by the etching method. The circuit pattern was mostly prepared in the right angle in the shape of a grid length and beside the substrate like drawing 2 . On the rear face and the front face, it was made to rotate 90 degrees, and the above-mentioned circuit pattern produced, and showed the distribution from which the magnetic field strength of the core of a grid becomes max. Others produced the display device like the example 1, using this as an electric wiring layer. The image which passed and acquired the current to electric wiring was clear.

[0057] On both sides of the polycarbonate substrate of 5100 micrometer thickness of examples, the copper film of 5-micrometer thickness was produced with vacuum evaporation technique, patterning of this copper film was carried out by the photolithography method, and copper wiring was formed by the etching method. The circuit pattern was made into the configuration of the character of KO of katakana like drawing 3 . On the rear face and the front face, it was made to rotate 90 degrees and the above-mentioned circuit pattern produced, and it doubled the location so that the magnetic field strength of the core of the character of KO might become max. Others produced the display device like the example 1, using this as an electric wiring layer. The image which passed and acquired the current to electric wiring was clear.

[0058] Pt layer for electroplating was prepared on example 6 silicon wafer. Besides, it is SiO2 of about 20-micrometer thickness with a CVD method. The film was produced. Besides, PMMA (polymethylmethacrylate) was prepared with the spin coat method. Subsequently, after exposing a grid-like hole pattern on PMMA, Cr layer was prepared with vacuum deposition etc. on PMMA. The hole was produced in PMMA and Cr layer using reactive ion etching. subsequently, the hole which did in this way and was formed regularly -- Fe3 O4 / polyethylene mixing black particle produced in the example 1 were put into inside, and the PMMA film of 20-micrometer thickness was stuck and covered. The memory layer and the electric wiring layer were prepared in the PMMA film side of 20-micrometer thickness like the example 1, and the display device was

produced. The image at the time of passing a current was clear.
[0059] To the configuration of the transparence base material / rotation particle layer / memory layer / electric wiring layer of example of comparison 1 example 1, the location of a memory layer and an electric wiring layer was replaced, it was made the configuration of a transparence base material / rotation particle layer / electric wiring layer / memory layer, and the rest produced the display device like the example 1. Although the same current as an example 1 was passed in the electric wiring layer, between a rotation particle layer and memory layers became large, the reinforcement of the field which rotates the magnetic particle of a rotation particle layer decreased, and image contrast was one half extent of an example 1.
[0060] The memory layer of example of comparison 2 example 1 was used as the mixed (volume ratios 8/2) spreading layer of a ferrite and resin. Thickness was thickened and surface inductive flux was made the same as an example 1. The film showed isotropic magnetic properties. Others produced the display device like the example 1. When the current was passed to electric wiring, since there were many components with the direction of a field of a memory layer parallel to a film surface, variation increased in the angle of rotation of a magnetic particle, and the image became what faded. Moreover, since memory thickness became thick, the generating field of an electric wiring layer was insufficient for memory layer magnetization, therefore the angle of rotation of a particle became inadequate, and the display image was indistinct.
[0061] In example of comparison 3 example 1, the display device was completely similarly produced except having set particle size of a magnetic particle to 5 micrometers, 32 micrometers, and 46 micrometers. The clearness of an image was lost as the thing using a magnetic particle with large particle diameter, and the image by the magnetic particle of 32 micrometers and the diameter of 46 micrometer was not clearly seen rather than the image by the magnetic particle of 5 micrometers and the diameter of 15 micrometer, but was that of ******.
[0062] In example of comparison 4 example 1, after enclosing the magnetic particle which consists of a magnetic-substance ultrafine particle and a polymer into a transparent microcapsule, it has arranged to the polycarbonate substrate without immersing a silicone oil between this microcapsule and a particle. Even if others added the field like the example 1, a particle did not rotate within the capsule and the image was not displayed.
[0063]
[Effect of the Invention] As mentioned above, according to invention of claim 1, the thin lightweight display device in which clear image display is possible can be obtained with a low power by forming a memory layer with the perpendicular magnetic-anisotropy film, approaching an image display layer and arranging.
[0064] According to invention of claim 2, the image of a high resolution can be displayed by setting mean particle diameter of a magnetic particle to 5 micrometers - 30 micrometers.
[0065] According to invention of claim 3, by arranging the magnetic particle connoted to the microcapsule in the image display layer, a rotation function is given to a magnetic particle and a clear image can be displayed by the field.
[0066] While a rotation function is given to a magnetic particle by enclosing a magnetic particle into the hole regularly prepared in the plate of transparence in the image display layer according to invention of claim 4, a magnetic particle can be arranged more regularly and an image with high resolution can be displayed.
[0067] According to invention of claim 5, monochrome image or a color picture can be easily displayed by the magnetic particle's having classified by color the semi-sphere every, while supposing that it is white.
[0068] According to invention of claim 6, by using the big nitriding iron of saturation magnetization for the magnetic substance of a magnetic particle, the big running torque to a magnetic particle is obtained, and an image can be formed with few current values.
[0069] According to invention of claim 7, the electric wiring layer which can control rotation of a magnetic particle by the manufacturing cost of low cost per pixel easily can be obtained by preparing the circuit pattern of an electric wiring layer in the shape of a grid on both sides of an insulating layer.

[0070] According to invention of claim 8, by carrying out current control by wiring 21 set so that the current of parallel conductive wiring with which an electric wiring layer adjoins each other may flow to hard flow mutually, big rotating magnetic field can be obtained at the core of the grid formed on both sides of an insulating layer with a circuit pattern, and an image can be formed in it with few current values.
[0071] According to invention of claim 9, by forming a coil configuration to which the character of KO laps with the part which intersects each conductive wiring of an electric wiring layer through an insulating layer, big rotating magnetic field can be obtained at the core of the character of KO, and an image can be formed in it with few current values.
[0072] According to invention of claim 10, by forming an antireflection film in the transparence base material of an image display layer, a flicker of an image can be controlled and a clear image can be observed.
[0073] According to invention of claim 11, by using the transparence base material of an image display layer, and the base material of an electric wiring layer as the same ingredient, the gap by the temperature change or humidity can be controlled between an image display layer and an electric wiring layer, the image gap at the time of rewriting can be prevented, and a clear image can be formed.
[0074] According to invention of claim 12, by using a pivotable magnetic pen for a magnetic particle from on the transparence base material of an image display layer, an image can be added to arbitration in handwriting, or it can eliminate.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to the magnetic particle rotation mold display device which the optical condition on the front face of a particle changes with rotations of the particle which consists of the magnetic substance, and displays images, such as a graphic form and an alphabetic character.

[Translation done.]

PRIOR ART

[Description of the Prior Art] MPD (magnetic particle display) which rotates a particle by the field was proposed by Magnavox in 1975 (L. L.Lee:IEEE Transaction on Electron Devices, ED-22, P758). The magnetic-substance spherical particle which white and the remaining semi-sphere side were colored for the semi-sphere side black was used for this MPD. Then, each particle is microencapsulated and it is improved by the approach of covering a transparence sheet with this.
[0003] As drawing 4 shows the example of a configuration of Above MPD and shows it to (a), the laminating of the substrate 5 is carried out to the rotation particle layer 2 which displays an image with the surface color of the rotation particle 1 sequentially from a top, the electric wiring layer 3 which has a field generating function, and the memory layer 4 which is magnetized by the electric wiring layer 3 and gives rotating magnetic field to the rotation particle layer 2. Endocyst is carried out to a microcapsule 6 and the rotation particle 1 which becomes the rotation particle layer 2 from the magnetic substance of the iron oxide classified by black and white by color is arranged, as shown in drawing 4 (b). As shown in both sides of base material 3a which consist of polyimide at drawing 4 (c), the copper wiring 3b and 3c is spread around in the shape of an X-Y matrix, and the electric wiring layer 3 is constituted, and reverses the magnetization direction of the magnetic layer of the part equivalent to the pixel section by the magnetic field of the field surrounded by two X each Rhine and Y lines. The memory layer 4 consists of a magnetic layer with a thickness of several mm, and it is divided into the prism of a pixel unit in the shape of a grid that magnetic shape anisotropy should be used so that it may expand to drawing 4 (d) and may be shown, and a field can be perpendicularly impressed to the rotation particle layer 2. This pixel size of MPD is 0.5-1.7mm, and the rotation particle with a particle diameter of 30-400 micrometers was used.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As mentioned above, according to invention of claim 1, the thin lightweight display device in which clear image display is possible can be obtained with a low power by forming a memory layer with the perpendicular magnetic-anisotropy film, approaching an image display layer and arranging.
[0064] According to invention of claim 2, the image of a high resolution can be displayed by setting mean particle diameter of a magnetic particle to 5 micrometers - 30 micrometers.
[0065] According to invention of claim 3, by arranging the magnetic particle connoted to the microcapsule in the image display layer, a rotation function is given to a magnetic particle and a clear image can be displayed by the field.
[0066] While a rotation function is given to a magnetic particle by enclosing a magnetic particle into the hole regularly prepared in the plate of transparence in the image display layer according to invention of claim 4, a magnetic particle can be arranged more regularly and an image with high resolution can be displayed.
[0067] According to invention of claim 5, monochrome image or a color picture can be easily displayed by the magnetic particle's having classified by color the semi-sphere every, while supposing that it is white.
[0068] According to invention of claim 6, by using the big nitriding iron of saturation magnetization for the magnetic substance of a magnetic particle, the big running torque to a magnetic particle is obtained, and an image can be formed with few current values.
[0069] According to invention of claim 7, the electric wiring layer which can control rotation of a magnetic particle by the manufacturing cost of low cost per pixel easily can be obtained by preparing the circuit pattern of an electric wiring layer in the shape of a grid on both sides of an insulating layer.
[0070] According to invention of claim 8, by carrying out current control by wiring 21 set so that the current of parallel conductive wiring with which an electric wiring layer adjoins each other may flow to hard flow mutually, big rotating magnetic field can be obtained at the core of the grid formed on both sides of an insulating layer with a circuit pattern, and an image can be formed in it with few current values.
[0071] According to invention of claim 9, by forming a coil configuration to which the character of KO laps with the part which intersects each conductive wiring of an electric wiring layer through an insulating layer, big rotating magnetic field can be obtained at the core of the character of KO, and an image can be formed in it with few current values.
[0072] According to invention of claim 10, by forming an antireflection film in the transparence base material of an image display layer, a flicker of an image can be controlled and a clear image can be observed.
[0073] According to invention of claim 11, by using the transparence base material of an image display layer, and the base material of an electric wiring layer as the same ingredient, the gap by the temperature change or humidity can be controlled between an image display layer and an electric wiring layer, the image gap at the time of rewriting can be prevented, and a clear image can be formed.
[0074] According to invention of claim 12, by using a pivotable magnetic pen for a magnetic

particle from on the transparence base material of an image display layer, an image can be added to arbitration in handwriting, or it can eliminate.

[Translation done.]

* NOTICES *

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] By the way, there were the following troubles in Above MPD.
** Although the particle of a rotation particle layer was slowly rotated by the field of a memory layer after magnetizing a memory layer first at high speed by the generating field of an electric wiring layer, with the configuration of a rotation particle layer / electric wiring layer / memory layer, since the memory layer which gives rotating magnetic field is separated with the rotation particle layer, it is hard to tell the field of a memory layer, and dispersion arises in particle rotation, and it was hard to obtain a clear image.
[0005] ** Since it was separated with the rotation particle layer, big record magnetic field strength was required for the memory layer, and in order to obtain record magnetic field strength with the big memory layer of a thick film, it needed to enlarge the generating field of an electric wiring layer.
** since the particle diameter of a rotation particle is as large as 30 micrometers or more -- an image -- resolution was low.
** Although the memory layer was formed in the shape of a grid, since production of such a complicated configuration was difficult, its production cost was high.
[0006] By this invention having coped with the trouble of the above-mentioned conventional technique, having been made, and making a memory layer an easy configuration thinly, and approaching a rotation particle layer and preparing, manufacture is easy and it aims at offering a low power and the magnetic particle rotation mold display device of a high resolution.

[Translation done.]

MEANS

[Means for Solving the Problem] Namely, the image display layer in which the magnetic particle which invention of claim 1 was classified by color possible [a color substitute] by rotation, and was magnetized is arranged pivotable on a transparence base material, The electric wiring layer which generates the field which rotates said magnetic particle per pixel of said image display layer, It is the magnetic particle rotation mold display device characterized by providing the memory layer which has the perpendicular magnetic anisotropy which is inserted between said image display layers and electric wiring layers, is magnetized by said electric wiring layer, and gives a field to the magnetic particle of said image display layer.
[0008] In invention of claim 1, if the current controlled by the electric wiring layer based on the picture signal flows and the field of the pixel unit corresponding to a picture signal occurs, it will be magnetized per pixel and a memory layer will give the field of the pixel unit corresponding to a picture signal to the magnetic particle of an image display layer. Thereby, each magnetic particle of an image display layer is controlled by the rotation condition corresponding to a picture signal, and an image is formed of the color which each magnetic particle turned to the transparence base material side. The image by rotation of each of this magnetic particle is held by the memory layer until the following field occurs by the electric wiring layer. While becoming possible by a memory layer approaching an image display layer, and it being prepared, and having a perpendicular magnetic anisotropy here to form with a thin film, without forming a memory layer in the prism of a pixel unit, record magnetic field strength is small, and it ends, and is attained, reduction-izing, i.e., power-saving, of a current which flows in an electric wiring layer.
[0009] Invention of claim 2 is characterized by being in the range whose mean particle diameter of a magnetic particle is 5 micrometers - 30 micrometers in the magnetic particle rotation mold MAG display device of claim 1. By setting mean particle diameter of a magnetic particle to 30 micrometers or less, pixel size can be set to 126 micrometers or less, and it becomes possible to obtain 200 or more dpi and a high-resolution image. Moreover, if particle diameter is set to 5 micrometers or less, the magnetization per piece will become small and rotation by the field will become difficult.
[0010] Invention of claim 3 is characterized by enclosing the magnetic particle with the lubricative liquid pivotable in a transparent microcapsule in the magnetic particle rotation mold MAG display device of claim 1. In this invention, it is endocyst's being carried out to a microcapsule and arranged on a transparence base material, and by the field, rotation of a magnetic particle is attained and the clear image formation of it becomes possible.
[0011] Invention of claim 4 is characterized by enclosing the magnetic particle into the hole regularly prepared in the plate of transparence in the magnetic particle rotation mold MAG display device of claim 1. In this invention, it is that a magnetic particle is enclosed into the hole prepared regularly, it becomes easy to arrange a magnetic particle more regularly, while rotation becomes free by the field like the condition that endocyst was carried out to the microcapsule, and an image with high resolution is obtained.
[0012] In the magnetic particle rotation mold MAG display device of claim 1, a magnetic particle is classified by semi-sphere every 2 colors by color, and invention of claim 5 is characterized by one color being white. A monochrome image is displayed when all the magnetic particles arranged

by the image display layer are classified by black and white by color. A color picture is displayed, when two or more colors are used combining white and it is arranged by the image display layer.
[0013] Invention of claim 6 is characterized by a magnetic particle containing nitriding iron in the magnetic particle rotation mold MAG display device of claim 1. In this invention, it is using the big nitriding iron of saturation magnetization for the magnetic substance of a magnetic particle, and big running torque is obtained and it becomes possible with few current values, the roll control, i.e., the image formation, of a magnetic particle.
[0014] Invention of claim 7 is characterized by having the circuit pattern layer of the pair by which conductive wiring was prepared in parallel in the direction in which an electric wiring layer intersects perpendicularly mutually through an insulating layer in the pixel pitch, respectively in the magnetic particle rotation mold MAG display device of claim 1. In this invention, while being preparing in the shape of a high grid so that a circuit pattern's may not be mutually touched in the direction of X, and the direction of Y and becoming possible to generate a field per pixel, production of an electric wiring layer is easy and a cheap display device is obtained.
[0015] Invention of claim 8 is characterized by being controlled so that the current of parallel conductive wiring with which an electric wiring layer adjoins each other flows to hard flow mutually in the magnetic particle rotation mold MAG display device of claim 7. In this invention, since the big rotating magnetic field at the core of the grid formed with the circuit pattern of the direction of X and the direction of Y are obtained, it becomes possible with few current values, the roll control, i.e., the image formation, of a magnetic particle.
[0016] In the magnetic particle rotation mold display device of claim 1, invention of claim 9 is characterized by having a coil configuration to which the character of KO laps with the part to which each conductive wiring crosses through an insulating layer while coming to prepare conductive wiring in a pixel pitch in the direction in which an electric wiring layer intersects perpendicularly mutually through an insulating layer, respectively. In this invention, since the big rotating magnetic field at the core of the character of KO of a part that conductive wiring crosses through an insulating layer are obtained, it becomes possible with few current values, the roll control, i.e., the image formation, of a magnetic particle.
[0017] Invention of claim 10 is characterized by forming the antireflection film in the transparence base material of an image display layer in the magnetic particle rotation mold display device of claim 1. In this invention, the color tone of a magnetic particle becomes clearer, a flicker of an image is controlled, and a clearer image is obtained.
[0018] Invention of claim 11 is characterized by the transparence base material of an image display layer and the base material of an electric wiring layer consisting of same ingredients in the magnetic particle rotation mold display device of claim 1. In this invention, the gap by telescopic motion of the base material accompanying a temperature change or humidity is controlled between an image display layer and an electric wiring layer, the image gap at the time of rewriting is prevented, and clear image formation becomes possible.
[0019] Invention of claim 12 is characterized by providing the magnetic pen which generates the field which rotates a magnetic particle from on the transparence base material of an image display layer in the magnetic particle rotation mold display device of claim 1. In this invention, it becomes possible to add an image to arbitration with a magnetic pen, or to eliminate from on a transparence base material.
[0020]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained based on a drawing. Drawing 1 is the sectional view showing the gestalt of 1 operation of the magnetic particle rotation mold display device of this invention. In this drawing, the magnetic particle 12 by which two or more color usual was classified by color in two colors is arranged by the base material 11 of transparence pivotable from the surface observation side. Sequential arrangement of the electric wiring layer 21 by which the memory layer 15 and base material 16 with which the protective coat 14 was formed were arranged, pattern formation of the electric wiring 18a and 18b was carried out to both sides of the base material 17 which serves as an insulating layer further, and protective coats 19 and 20 were formed in this rotation particle layer 13, and the base material 22 is carried out. Moreover, an antireflection film (not shown) is

prepared in the base material 11 of the rotation particle layer 13 if needed.
[0021] The magnetic particle 12 contains the magnetic substance, it is magnetized so that it might be classified by two colors by color, while N pole and another side may become the south pole in them, and it serves as a permanent magnet. As a magnetic particle 12, the mixture of the ultrafine particle of the magnetic substance and polymers, such as polyethylene and phenol resin, is used. Moreover, a magnetic-substance independent particle may be used. In this case, magnetization becomes strong rather than mixture with a polymer, therefore the torque for rotation becomes strong. For this reason, since the magnetic field strength which rotation takes is small, it ends and the current value of the electric wiring layer 21 can be reduced, power-saving can be attained. Although an ellipse and a polygon are sufficient as the configuration of the magnetic particle 12, in order to rotate smoothly, its globular form is desirable.
[0022] The particle diameter of the magnetic particle 12 has desirable 30 micrometers or less. Although the rotation particle with a particle size of 30 micrometers or more was used in MPD of the conventional technique, when it is going to obtain 200 or more dpi and a high-resolution image, this is because it was the magnitude whose pixel size is 0.5-1.7mm, pixel size is set to 126 micrometers or less, the particle size of a magnetic particle is too large in 30 micrometers or more, and sufficient resolution is not obtained. On the other hand, if particle diameter is not much small, the magnetization per piece will become small and rotation of it by the field will become impossible. Moreover, rotation functional grant processing, for example, microencapsulation etc., becomes difficult. Although based also on the saturation magnetization of the magnetic substance used for the magnetic particle 12, 5 micrometers or more are desirable.
[0023] Moreover, since magnetization will become small if the particle size of the magnetic substance becomes small, as the magnetic substance, the larger one of saturation magnetization becomes large and is desirable [running torque]. Saturation magnetization is as large as 120 - 140 emu/g twice [about], and the iron oxide (gamma-Fe 2O3 and Fe 3O4) of nitriding iron (Fe4 N) generally used is desirable, although saturation magnetization is 70 - 80 emu/g.
[0024] Although coercive force of the magnetic substance is the half-hard magnetism object or hard magnetism object of 50 or more Oes and the color is generally black, other colors, such as yellow, and brown or green, are sufficient. As the black magnetic substance, there are various ferrites, such as Fe, Co, nickel, Fe 2O3, Fe 3O4, Co ferrite, and a MnZn ferrite. What is necessary is to color only a semi-sphere white, if the magnetic substance is black although the color of the magnetic particle 12 is usually classified by two colors of white and black by color a semi-sphere every. The background color is chosen instead of white to carry out the color of a background in addition to white. The so-called coloring of red (R), green (G), blue (B), etc. in three primary colors is performed with white to obtain a color picture. Three or more colors may be colored depending on the case. For example, FURUKARA can be displayed if it has classified by color in five colors of the above-mentioned white and black. As a particle coloring matter in three primary colors, colors, such as a methylene blue, Congo Red, and the benzoyellow TZ, oil blue, oil cleanness, oil yellow, benzidine yellow, etc. are used. Moreover, the color tone of the magnetic particle 12 can check now more clearly by preparing an antireflection film on the rotation particle layer 13 in which the magnetic particle 12 was arranged.
[0025] In order to color white one side of black and each color particle of R, G, and B, there is the approach of putting the aluminum film using vacuum deposition methods, such as a coating method and a spray method, although many things are considered, after forming a particle further and fixing as easiest approach. Although the aluminum film has metallic luster, if it becomes the particle of the diameter of 5-30 micrometer, this metallic luster will no longer be sensed and will be observed as the so-called white. The front face of the magnetic particle 12 classified by color may be thinly coated with the organic substance or an inorganic substance, in order to decrease surface irregularity, or in order to raise surface lubricity.
[0026] A rotation function is given to the magnetic particle 12 which was colored as mentioned above and magnetized, and it is arranged on a base material 11. Although there are some approaches of giving a rotation function, the approach of enclosing the magnetic particle 12 with a transparent microcapsule as one is mentioned. independent [in common resin, such as acrylic,

an methacrylic system, polyester, polystyrene, poly urea, a polyamide, and epoxy,] as an ingredient which constitutes the outer shell of a microcapsule -- or it can be mixed and used. in-situ which supplies a monomer as the manufacture approach of a microcapsule from one side of the internal phase of an emulsion or external phase who distributed the interfacial polymerization which supplies both the inside of an emulsion, and an outside to the monomer which distributed the magnetic particle, and a magnetic particle -- law and other well-known microencapsulation techniques are used. Properties, such as a certain amount of [the outer shell of a microcapsule] mechanical strength which pushes and bears **, transparency, and chemical stability, are searched for. Moreover, a lubrication action for the fluid made to contain in a microcapsule to make rotation of the magnetic particle 12 smooth is called for most, and liquids, such as water, an oil, and alcohol, are used.

[0027] The magnetic particle 12 to which the rotation function was given is arranged on the transparent base material 11. Although it is desirable to arrange various ****s and the same size particle only one layer regularly also to this array approach, about 1.5 layers or two sorts of size particles may be arranged to a multilayer. As a transparence base material, transparence resin, such as MMA (methyl methacrylate), PMMA (polymethylmethacrylate), a polycarbonate, polypropylene, acrylic resin, styrene resin, ABS plastics, polyarylate, Pori Sall John, a polyether ape phon, an epoxy resin, the Polly 4-methyl pentene -1, fluorination polyimide, a fluororesin, phenoxy resin, polyolefine system resin, and Nylon, is used.

[0028] There is a method of making a particle enclose into the hole regularly prepared in the plate made of a transparent plastic as an approach in the case of arranging the same size particle only one layer regularly. It is the size into which the height of a hole can rotate one particle and, as for length and width, plurality goes. In this case, the microcapsule which gives a rotation function to the magnetic particle 12 does not have the need. It becomes instead of the hole of a transparence plastic sheet being a microcapsule. It is still better if the liquid for frictional resistance reduction (for example, oil) is enclosed into this hole. Since the advantage of this approach can arrange a particle regularly, it is that a high quality picture is obtained. In addition, as for this approach, it is needless to say that it can arrange also at random.

[0029] As an approach of forming a hole, the following approaches are in this transparence plastic sheet (J Vac Sci Technol B Vol.16, No.6 p.3825-3829, 1998 reference).

1. For example, prepare on a silicon wafer, the metal, for example, Pt layer, for electroplating.
2. It is SiO2 with a CVD method etc. on this. The film is made. It is ****** about the depth of the hole into which this thickness puts a particle.
3. Prepare PMMA with a spin coat method etc. as a transparent plastic on this.
4. Expose a hole pattern on PMMA with lithography.
5. Prepare Cr with vacuum deposition etc. on PMMA.
6. Form a hole in PMMA and Cr layer by reactive ion etching.

[0030] Unlike the conventional MPD, the memory layer 15 is formed in contact with the rotation particle layer 13. Moreover, the memory layer 15 consists of a magnetic layer which has a perpendicular magnetic anisotropy, and is formed in uniform thickness. That is, the perpendicular magnetic anisotropy films 2 or more KOes of whose perpendicular magnetic-anisotropy constants Hk are 4 or more KOes preferably are used as a memory layer 15. Since a big generating field is acquired by the perpendicular direction of a memory stratification plane rather than the case of the magnetization film within a field of the same thickness by using these perpendicular magnetic anisotropy films, a memory layer can be made thin more.

[0031] The memory layer 15 has the function to hold the rotation condition and to prevent turbulence of an image while supporting rotation of the magnetic particle 12 of the rotation particle layer 13 by the field of the memory layer 15 which was magnetized by the field generated by the electric wiring layer 21, and was magnetized further. That is, although the direction of a generating field of the electric wiring layer 21 is changed by making the direction of a current reverse, it magnetizes the specified location corresponding to the pixel of the memory layer 15 to + or - according to this generated direction of a field. Every pixel is sufficient as this magnetization, and every two or more pixels are sufficient as it. Since speed of this 1-pixel magnetization can be carried out at 1 or less microsecond and a high speed, it is possible to the

order of a second also at a big screen, for example like A4 size. When this memory layer 15 does not exist, it is necessary to rotate the magnetic particle 12 by the field of the electric wiring layer 21 for every particle. even if magnetic particle rotation is quick -- 20 -- since it takes about m seconds, in A4 size, it will cut in long duration. There are various the field impression approaches by the electric wiring layer 21, if the approach of impressing [two or more] to coincidence every is used, an image will be obtained quickly, but if the number of pixels impressed to coincidence increases, the current value which flows to coincidence will also increase indeed. Since it is difficult practically to pass the current more than 1A in respect of equipment size etc., the memory layer 15 is indispensable in order to obtain an image at high speed.

[0032] Moreover, it is necessary to fix the rotated magnetic particle 12 to re-rewriting at the time of the next roll control so that an image may not change. Also in this case, since magnetization of the memory layer 15 does not change with time amount by forming the memory layer 15, the magnetic particle 12 which is a permanent magnet is fixed, with the same direction turned to. In addition, as an approach of fixing the magnetic particle 12 after rotation, there is also an approach using the thixotropy liquid with which resistance increases after rotating between the magnetic particle 12 and resin layers, such as a microcapsule, besides installation of the memory layer 15.

[0033] By the way, in order to rotate the magnetic particle 12, it is required to give attraction and repulsive force to magnetization of the particle which was made to generate a field at right angles to the field of this display device, and was permanent-magnet-ized. Although it enables it to impress a field to a direction for the magnetic material which has plane anisotropy perpendicularly as a long configuration in MPD of the conventional technique using magnetic shape anisotropy, with the gestalt of this operation, a perpendicular magnetic anisotropy is given to memory layer 15 the very thing, and a particle is rotated by the field perpendicularly generated in a display device side. By using these perpendicular magnetic anisotropy films, it is not necessary to process the magnetic substance in the shape of a column for every pixel, since processing of a uniform layer is sufficient, manufacture can become easy, therefore cost can be reduced sharply.

[0034] As an approach of creating the perpendicular magnetic anisotropy films which have a perpendicular magnetic anisotropy, a hexagon-head plate is put in order, the coating of the magnetic-substance powder which has a hexagon-head tabular configuration like a barium ferrite, for example is applied in parallel with a substrate side, impressing a magnetic field, (orientation), and there is the approach of creating perpendicular magnetic anisotropy films. Between rolls of the mixture of a barium ferrite and resin is passed similarly, and there is also the approach of carrying out orientation of each particle and producing in the shape of sheet metal. Moreover, there is the approach of producing on a substrate metallic compounds, such as TbFeCo widely used as magneto-optic-recording material media, by PVD, such as a spatter. There are also an approach of producing with plating the ingredient which otherwise has perpendicular magnetic anisotropies, such as PtCo, and the approach of producing with a sol-gel method. Neither an ingredient nor the production approach is limited in this invention. With an ingredient with sufficient stability, it is more thin and the approach of being easy to make is selected.

[0035] Next, the electric wiring layer 21 used for magnetization of the memory layer 15 is explained. a current flows to electric wiring 18a and 18b -- the magnetic particle 12 can be rotated within a microcapsule by the interaction (attraction or repulsive force) of the residual magnetization of the magnetic field to generate and each magnetic particle 12. Since magnetic field strength required for rotation is small good at about 10 gauss, electric wiring 18a and 18b is possible by the approach of wiring so that it may prepare in X and the direction of Y in the shape of a straight line, respectively and the grid of each other may be formed. In this case, there is an advantage that a wiring configuration is simple and production is easy. Two main tracks are used as one pair, respectively, a current is passed to hard flow in two main tracks, and you may make it make the target pixel generate a field in the direction of X, and the direction of Y in that case, as shown in drawing 2 .

[0036] Out of this, electric wiring 18a and 18b may be made to correspond to each pixel at each

single track of X and the direction of Y, as shown in drawing 3 , and a horseshoe-shaped coil may be prepared, and you may form so that the coil of that one turn may lap through an insulating layer in X and the direction of Y. If the coil of 2 or more ******s is prepared, of course corresponding to each pixel location, a current value required for excitation is small, and it ends, and although it is desirable, it will be necessary to become unproducible at a monolayer, and wiring will need to consist of multilayers which include an insulating layer in the middle. Moreover, it becomes difficult to double an up-and-down wiring location. In addition, the generating strong magnetic field by electric wiring and the location of a pixel are produced so that it may be in agreement.

[0037] electric wiring 18a and 18b -- the above -- also in which wiring approach, the field has occurred besides the target pixel section, and a threshold is required for the force required for rotation of the magnetic particle 12 so that it may be pivotable in the magnetic particle 12 only in the target pixel section. Such a threshold is controlled by viscosity of a microcapsule and the liquid between magnetic particles etc. Viscosity control material, such as sodium alginate, polyvinyl alcohol, denaturation sodium polyacrylate, a denaturation polyacrylic acid emulsion, and a denaturation polyacrylic acid sulfonate, is used for the viscosity control of such a liquid. Especially, sodium alginate and polyvinyl alcohol are desirable.

[0038] Moreover, also in which wiring approach, electric wiring 18a and 18b can form a copper layer in the flesh side of insulating layers, such as a polyimide film, and both sides of a table with vacuum deposition, a spatter, plating, etc., and can form it by etching this copper layer except for a circuit pattern. Besides this photolithography method, a replica method can be used and a circuit pattern can also be formed. For example, it patternizes after forming a resist on 1. conductivity substrate. 2. Prepare a metal, for example, copper, by the electroplating method on this. 3. Make adhesives adhere with plating on this. 4. Turn this adhesive coated surface down, for example, imprint on a plastic plate, and form electric wiring. This replica method can respond to a large area easily by low cost, and it has the advantage that creation of super-thin wiring or solid wiring is easy. In addition, although the common copper of the ingredient used for electric wiring is desirable from the point of an electric resistance value, the conductive ingredient of others, such as Au, Ag, aluminum, and Pt, is also used. Moreover, the common ITO film as transparence electric conduction film may be used.

[0039] Moreover, in order to prevent the damage on a blemish, exfoliation, etc., as signs 14, 19, and 20 show to drawing 1 It is desirable from the point of the endurance of a device to prepare a protective coat. SnS, aluminum2 O3 / [SiO, SiO2, ITO, ZrC, TiC and MgF2, MgO, BeO and ZrO2, Y2 O3, aluminum 2O3, and] Ta 2O5, SiAlON, AlN, Si3 N4, SiCN:H, etc. are used. As an organic resin protective coat, the photo-setting resin constituent and heat photo-setting resin constituent which use a polymerization nature monomer and oligomer as a principal component can be used. 50-1000nm of thickness is desirable.

[0040] It not only forms by the above-mentioned electric wiring layer 21, but the image of the rotation particle layer 13 can be formed again from the side which looks at, the opposite side, i.e., the image, of a base material 11. For example, it is also possible to carry out image formation with the magnetic pen which established the iron core into the coil and was used as the nib. When it can write in only at the time of energization of a certain direction and energizes in the direction contrary to this, the nib is possible in combination with a magnetization setup of the magnetic particle 12 so that an image can be erased. Although it is necessary to reverse a tip mechanically and inconvenient when a thin cylinder-like permanent magnet is used as a nib, when an electromagnet is used, the direction of a field can be easily reversed by button grabbing.

[0041] In addition, when a field occurs in the pixel section, migration, i.e., postscript actuation, of a magnetic pen, a current flows in the electric wiring layer 21. If the current detector which detects this current is arranged at each wiring edge, even if it does not arrange image sensing elements, such as a touch panel, specially, a postscript image is easily recordable on a display and coincidence by low cost.

[0042] As stated above, the color picture of the magnetic particle 12 also becomes possible not only black and white but by controlling particle rotation by the magnetic field generated by the

electric wiring layer 21, since it can be further colored **** of R, G, and B. In this case, the magnetic particle 12 colored by each color of black and white and RGB can also change and arrange coercive force and magnetic classes (antiferromagnetism etc.).

[0043] Moreover, the base material 11 which is a clear layer having protection of a component front face and the function of a base material is formed in a display device maximum front face. It will let this base material 11 pass, and the image contrast made by the magnetic particle 12 will be observed. In this case, the light reflected by the front-face side of a base material 11 becomes the factor which disturbs an image. Therefore, a clearer image can be obtained by preparing the antireflection film for preventing this reflected light generating. The stable matter is thermally [transparently / the ingredient used for an antireflection film] suitable. For example, the oxide of a metal or semimetal, a nitride, a chalcogen ghost, a hooker object, They are carbide and such mixture. Specifically SiO2, SiO, aluminum 2O3, GeO2, In 2O3, Ta 2O5, and TeO2, They are simple substances or these multilayers, such as TiO2, MoO3, WO3, ZrO2, Si3 N4, AlN, BN, TiN, ZnS and CdS, CdSe, ZnSe, ZnTe, AgF and PbF2, MnF2, NiF2, and SiC. Each thickness is preferably good to make [5-200nm] it the range of 5-30nm. The film is formed using various kinds of PVD(s) and a CVD method.

[0044] Moreover, plastic material is used for the transparent base material 11 with which the rotation particle layer 13 is formed, and the base material 17 in which the electric wiring layer 21 is formed. Although this is for being light and making the whole display device thin, the telescopic motion of plastic material by heat or humidity is large. As for the image displayed once, a pixel location shifts in response to the effect of temperature or humidity. This gap becomes so large that it becomes a big screen. If it differs from the pixel location of the electric wiring layer 21 of a basis when displaying a new image on the same display device, the image part which cannot be overwritten will be generated. Therefore, since it writes in with the rotation particle layer 13 which is a display layer and the gap by temperature or humidity is not produced between the electric wiring layers 21 which are layers, it is desirable to use the same plastic material for the base material 11 of the rotation particle layer 13 and the base material 17 of the electric wiring layer 21. By this, it comes at the time of image rewriting to prevent the image gap by telescopic motion of a base material arising, and generating of the image by the electric wiring layer 21 which is not rewritable can be suppressed as much as possible.

[0045] In the gestalt of this operation, it is a light weight and a thin shape, and without destroying, even if deformation of some occurs, high definition image formation is possible at power saving, and a postscript can also obtain a possible magnetic particle rotation mold display device from on an image so that clearly also from the above-mentioned explanation. Although especially the memory layer was conventionally pillar-shaped and component thickness was thick, it became possible to make the whole equipment light thinly by using the thin film which has a perpendicular magnetic anisotropy. Moreover, 100mA or less of current values of the electric wiring layer which magnetizes a memory layer by approaching a rotation particle layer and installing the memory layer which supports magnetic particle rotation since magnetic particle rotation is possible at the magnetic field strength of several gauss usually became possible [a next door and displaying an image with a precision more sufficient at power saving] enough by 10mA or less at the maximum.

[Translation done.]

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

EXAMPLE

[Example] Hereafter, the example of this invention is explained.
Fe 3O4 whose example 1 mean particle diameter is 0.2 micrometers The ultrafine particle was distributed to the polyethylene solution. It was heated by about 100 degrees C and the circumference edge under rotation trickled these dispersion liquid into the tooth form-like disk by 30000RPM. It quenched the particle which collided with this rotating disk and dispersed, and it became round the shape of a true ball so that surface energy might be lowered. Uptake of this particle was carried out to the drum, and Fe3 O4 / polyethylene mixing (it is 1/1 at volume ratio) black particle whose mean particle diameter is 15 micrometers and whose maximum particle diameter is 30 micrometers were obtained.
[0047] After sprinkling the mixed globular form particle near this true ball so that it may become only one layer on a commercial pressure sensitive adhesive sheet, the opening was further filled up with the particle and it fixed. The vacuum deposition method was used on this fixed particle, and the aluminum thin film was formed in the thickness of about 100nm. The aluminum film is formed in the upper half (about 50% of white area) of a mixed particle, and is not put on a lower half. The particle on a sheet was observable in not a metallic color but the so-called white for the particle. The coercive force measured by VSM (oscillating sample mold magnetometer) was 108Oe(s), and residual magnetization was 67 emu/g. This particle firmly attached seat has been arranged between the pole piece of an electromagnet as it is, and it was magnetized so that the direction of the line which impresses a 100 gauss field and connects white and a black core, and magnetization might gather. Subsequently, each magnetic particle was exfoliated from the sheet.
[0048] The above-mentioned magnetic particle was put into the 55-degree C gelatin water solution, and was agitated. Gum arabic was added to this solution, it was made acidity, solution temperature was further lowered [PH was lowered,] to 20 degrees C or less, the polymer film of gelatin/gum arabic was generated and hardened, and the microcapsule was formed. This microcapsule is immersed into a silicone oil, a silicone oil is infiltrated between a microcapsule and a magnetic particle, and it enabled it to rotate a magnetic particle within a capsule. The monochrome color has been checked through the microcapsule.
[0049] Next, the antireflection film of MgO with a thickness of 100nm was prepared in one side of a polycarbonate substrate with a thickness of 100 micrometers with vacuum evaporation technique, and it was coated with ultraviolet-rays hardening resin in another field. The water solution of the microcapsule which carried out [above-mentioned] production was hung down to the ultraviolet-rays hardening resin spreading side of a polycarbonate substrate, and vibration was added so that a microcapsule might arrange by the thickness of only one layer. Then, irradiate ultraviolet-rays hardening resin, it was made to harden UV light, each microcapsule location was fixed, and the image display section was produced.
[0050] Next, perpendicular magnetic anisotropy films with a thickness of 0.5 micrometers were formed on the polycarbonate film with a thickness of 20 micrometers using the spatter by using TbFeCo as a target. The coercive force which impressed and measured the perpendicular direction field was 180Oe(s). Perpendicular anisotropy fields were 4.5KOe(s). The protective coat of SiN with a thickness of 100nm was similarly formed using the spatter on this film. Thus, on the protective coat of the produced memory layer, adhesives were used, and the polycarbonate

substrate of said image display section was ****ed outside, and was stuck in piles.
[0051] Next, after preparing nickel film of 10nm thickness in one side of a polycarbonate substrate with a thickness of 100 micrometers by the spatter, the copper film of 5-micrometer thickness was formed with plating. Patterning of this copper film was carried out by the photolithography method, and copper wiring was formed by the etching method. The circuit pattern was made into the coiled form of 3 turns. Moreover, the pitch between coils (i.e., between pixels) was set to 127 micrometers (200dpi). Then, the SiN film of about 100nm thickness was further prepared as a protective layer on the circuit pattern by the spatter. A drive circuit which a field with a coil generates one [at a time] one by one at the intersection of wiring of X and the direction of Y was established in each wiring edge. After uniting in piles the electric wiring layer produced as mentioned above with the lamination article of the image display section which arranged the microcapsule, and a memory layer like drawing 1 , the seal of the edge was carried out by resin, and the display device was produced.
[0052] Subsequently, the drive circuit was used for each electric wiring, and the current was passed one by one. The current controlled the direction with the magnetic pole of the magnetic particle on each coil (pixel) to oppose. It rotated and the magnetic particle showed black. Each pixel was able to be made to have been able to produce the migration to black and white similarly, contrast was able to be acquired, and monochrome image was able to be obtained. The image could be clear, without flickering and being visible with the reflected light in the front face of a transparence base material, and was able to indicate by the repeat. Moreover, the irregularity of a magnetic particle was not worried. The formed image did not disappear semipermanently until it rewrote it.
[0053] Furthermore, the coil was formed in the iron bar with a diameter [of 0.8mm], and a die length of 15mm, and it considered as the electromagnet, and with a cell and a switch, as the current flowed in the both directions of positive/negative, the magnetic pen for field generating in which an image can be entered from on the transparence base material of the image display section was produced. After passing and carrying out image formation of the current to the electric wiring layer of the above-mentioned display device, the current was passed in the forward direction on this magnetic pen, the pen was run from on the transparence base material, and the image was eliminated. Moreover, the current was passed in the negative direction and the line drawing image was newly added. Since the polycarbonate substrate of the same ingredient was used for the transparence base material of the image display section, and the base material of an electric wiring layer, there were few parts which were not able to carry out image rewriting, and the image was clear.
[0054] It sets in the example 2 example 1, and is Fe 3O4 with a mean particle diameter of 15 micrometers as a magnetic particle instead of Fe3 O4 / polyethylene mixing particle. The thickness of a microcapsule was made to double [about] in order to prevent with [which goes away between magnetic particles] ** using a black magnetic-substance particle. Others produced the display device like the example 1. The image which passed and acquired the current to electric wiring was clear. Moreover, from the magnetic rotation particle of an example 1, in spite of increase of the part to which saturation magnetization increased twice [about], and particle weight, particle running torque was able to increase, rotation was able to become possible with fewer current values, and power-saving was able to be attained.
[0055] It sets in the example 3 example 1, and is Fe 3O4 with a mean particle diameter of 0.2 micrometers. The black magnetic-substance particle of Fe4 N with a mean particle diameter of 0.2 micrometers was used instead of the ultrafine particle, and the mixed particle of Fe4 N / polyethylene was produced as a magnetic particle. Moreover, the thickness of a microcapsule was made to double [about] in order to prevent with [which goes away between magnetic particles] **. The image which others produced the display device like the example 1, and passed and acquired the current to electric wiring was clear. Moreover, from the magnetic rotation particle of an example 1, the part and particle running torque to which saturation magnetization increased twice [about] were able to increase, rotation was able to become possible with fewer current values, and power-saving was able to be attained.
[0056] On both sides of the polycarbonate substrate of 4100 micrometer thickness of examples,

the copper film of 5-micrometer thickness was produced with vacuum evaporation technique, patterning of this copper film was carried out by the photolithography method, and copper wiring was formed by the etching method. The circuit pattern was mostly prepared in the right angle in the shape of a grid length and beside the substrate like drawing 2 . On the rear face and the front face, it was made to rotate 90 degrees, and the above-mentioned circuit pattern produced, and showed the distribution from which the magnetic field strength of the core of a grid becomes max. Others produced the display device like the example 1, using this as an electric wiring layer. The image which passed and acquired the current to electric wiring was clear.
[0057] On both sides of the polycarbonate substrate of 5100 micrometer thickness of examples, the copper film of 5-micrometer thickness was produced with vacuum evaporation technique, patterning of this copper film was carried out by the photolithography method, and copper wiring was formed by the etching method. The circuit pattern was made into the configuration of the character of KO of katakana like drawing 3 . On the rear face and the front face, it was made to rotate 90 degrees and the above-mentioned circuit pattern produced, and it doubled the location so that the magnetic field strength of the core of the character of KO might become max. Others produced the display device like the example 1, using this as an electric wiring layer. The image which passed and acquired the current to electric wiring was clear.
[0058] Pt layer for electroplating was prepared on example 6 silicon wafer. Besides, it is SiO2 of about 20-micrometer thickness with a CVD method. The film was produced. Besides, PMMA (polymethylmethacrylate) was prepared with the spin coat method. Subsequently, after exposing a grid-like hole pattern on PMMA, Cr layer was prepared with vacuum deposition etc. on PMMA. The hole was produced in PMMA and Cr layer using reactive ion etching. subsequently, the hole which did in this way and was formed regularly -- Fe3 O4 / polyethylene mixing black particle produced in the example 1 were put into inside, and the PMMA film of 20-micrometer thickness was stuck and covered. The memory layer and the electric wiring layer were prepared in the PMMA film side of 20-micrometer thickness like the example 1, and the display device was produced. The image at the time of passing a current was clear.
[0059] To the configuration of the transparence base material / rotation particle layer / memory layer / electric wiring layer of example of comparison 1 example 1, the location of a memory layer and an electric wiring layer was replaced, it was made the configuration of a transparence base material / rotation particle layer / electric wiring layer / memory layer, and the rest produced the display device like the example 1. Although the same current as an example 1 was passed in the electric wiring layer, between a rotation particle layer and memory layers became large, the reinforcement of the field which rotates the magnetic particle of a rotation particle layer decreased, and image contrast was one half extent of an example 1.
[0060] The memory layer of example of comparison 2 example 1 was used as the mixed (volume ratios 8/2) spreading layer of a ferrite and resin. Thickness was thickened and surface inductive flux was made the same as an example 1. The film showed isotropic magnetic properties. Others produced the display device like the example 1. When the current was passed to electric wiring, since there were many components with the direction of a field of a memory layer parallel to a film surface, variation increased in the angle of rotation of a magnetic particle, and the image became what faded. Moreover, since memory thickness became thick, the generating field of an electric wiring layer was insufficient for memory layer magnetization, therefore the angle of rotation of a particle became inadequate, and the display image was indistinct.
[0061] In example of comparison 3 example 1, the display device was completely similarly produced except having set particle size of a magnetic particle to 5 micrometers, 32 micrometers, and 46 micrometers. The clearness of an image was lost as the thing using a magnetic particle with large particle diameter, and the image by the magnetic particle of 32 micrometers and the diameter of 46 micrometer was not clearly seen rather than the image by the magnetic particle of 5 micrometers and the diameter of 15 micrometer, but was that of ******.
[0062] In example of comparison 4 example 1, after enclosing the magnetic particle which consists of a magnetic-substance ultrafine particle and a polymer into a transparent microcapsule, it has arranged to the polycarbonate substrate without immersing a silicone oil

between this microcapsule and a particle. Even if others added the field like the example 1, a particle did not rotate within the capsule and the image was not displayed.

[Translation done.]

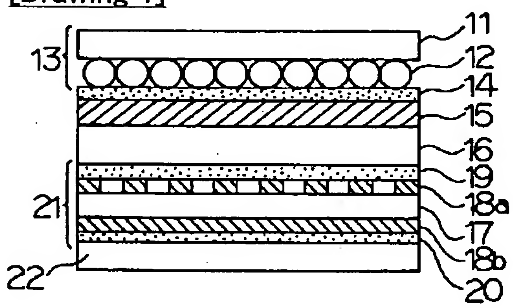
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the sectional view showing the magnetic particle rotation mold display device of the gestalt of 1 operation of this invention.
[Drawing 2] It is drawing explaining the field generating approach by the electric wiring concerning this invention.
[Drawing 3] It is drawing explaining the field generating approach by the electric wiring concerning this invention.
[Drawing 4] It is drawing showing the example of a configuration of MPD of the conventional technique.
[Description of Notations]
1 .... Rotation particle
2 13 .... Rotation particle layer
3 21 .... Electric wiring layer
4 15 .... Memory layer
6 .... Microcapsule
11, 16, 17, 22 .... Base material
12 .... Magnetic particle
14, 19, 20 .... Protective coat
18a, 18b .... Electric wiring

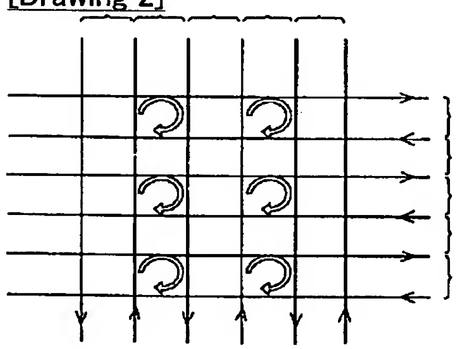
[Translation done.]

DRAWINGS

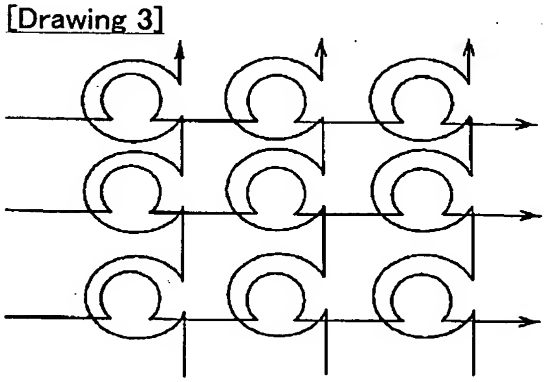
[Drawing 1]



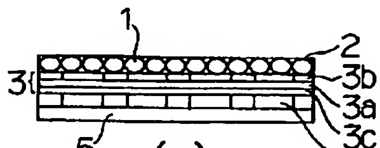
[Drawing 2]



[Drawing 3]



[Drawing 4]



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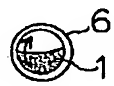

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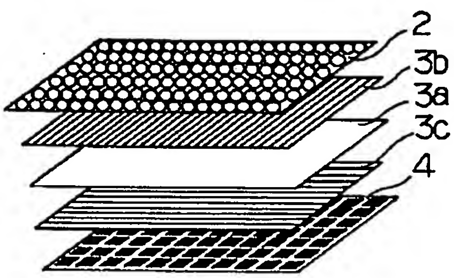
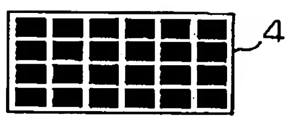


(c)



(d)

[Translation done.]